INSTRUCTION MANUAL

type 1395-P6
WORD GENERATOR

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GENERAL RADIO COMPANY

West Concord, Massachusetts

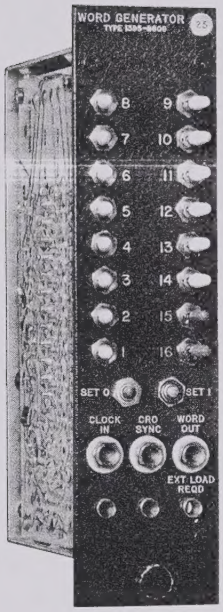


Figure 1-1. Type 1395-P6 Word Generator.

SPECIFICATIONS

INPUT

Pulse Repetition Frequency: Dc to 2.5 Mc/s, externally controlled by TYPE 1395-P1 PRF Unit (or similar unit).

Trigger-Pulse Requirements: 10- to 20-V positive-going pulses of 75- to 150-ns duration. Square waves can be used above 10 kc/s; sine waves, above 500 kc/s.

Impedance: 400 to 600 Ω, depending upon trigger amplitude.

OUTPUTS

Oscilloscope Sync: Rectangular pulse of 2-V min amplitude and duration equal to period of driving-signal prf. Occurs approx 50 ns before the switch #1 output pulse, whether or not the switch is on.

Word Out: 10- to 20-V positive-going pulses of 75- to 150-ns duration. Output impedance approx 150 Ω, but termination in 500 to 1000 Ω is recommended.

Pattern: Set by front-panel switches. Choice of 16-bit or 14-bit capacity by rear-panel switch. One can achieve capacities other than 14 and 16 by modification of internal wiring. Interconnection of up to seven units provided by the TYPE 1395-A main frame.

GENERAL

Power Consumption: +15 V at 5 mA; 6.3 V, 60 c/s, 0.8 A. Power supplied by frame.

Accessories Supplied: Five patch cords — one each TYPES 274-LSB, 274-LSR, 274-LMB, 274-LMR, and 274-LLR; two insulated plugs, one each TYPES 274-DB1 and 274-DB2.

Net Weight: 2½ lb (1.2 kg). **Shipping Weight:** 5½ lb (2.5 kg).

SECTION 1

INTRODUCTION

1.1 THE TYPE 1395-A MODULAR PULSE GENERATOR SYSTEM.

The General Radio Type 1395-A Modular Pulse Generator is a customized pulse generator made up of a main frame, which includes power supplies and adder circuits, and various plug-in modules. As requirements change, the plug-in modules can be rearranged in a few minutes to create exactly the pulse generator for the new circumstances. The Type 1395-P6 Word Generator described in this instruction book is one of the plug-in modules.

A number of modules are available: some determine the shape of a pulse; others determine pulse amplitude and duration; still others are amplifiers, pattern generators, or clocks. Wise interconnection of these modules is the key to success. A number of examples are given in the instructions for the Type 1395-A Modular Pulse Generator and in paragraph 2.2 of the instructions for this Word Generator, but practice and ingenuity will take the user far beyond the limits of any instruction book.

1.2 DESCRIPTION OF THE WORD GENERATOR, TYPE 1395-P6.

The Type 1395-P6 Word Generator produces a pattern of binary digits according to instructions set on front-panel switches. More than one Word Generator can be connected in cascade, up to the full seven-module capacity of the Type 1395-A main frame. Each Word Generator gives 16 binary digits (bits), so that a full set of seven Word Generators provides 112-bit capability. A switch on the rear panel converts the 16-bit-per-generator capacity to 14 bits per generator. Thus, just two Word Generators connected in various combinations of 16- and 14-bit capability give all the following options:

1	32-bit word
2	16-bit words
4	8-bit words
8	4-bit words
16	2-bit words
1	28-bit word
2	14-bit words
4	7-bit words
7	4-bit words
14	2-bit words
1	30-bit word
2	15-bit words
3	10-bit words
5	6-bit words
6	5-bit words
10	3-bit words
15	2-bit words

For other combinations, more than two Word Generators can be connected in cascade (refer to paragraph 2.2.6) or the internal wiring of a Word Generator can be changed with a patch cord (refer to paragraph 2.3.3).

Word Generators can be connected as scalers where one unit is driven from another (refer to paragraph 2.2.7). Binary, decade, or unusual scaling factors are possible (except for prime numbers greater than 112).

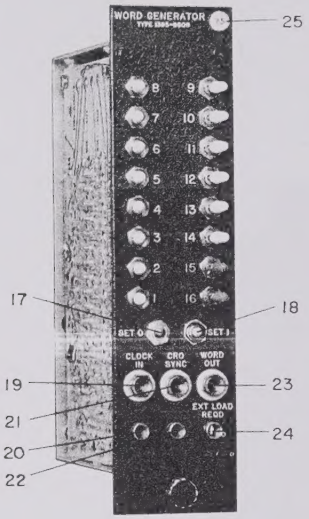


Figure 1-2. (left) Type 1395-P6 Word Generator. (For legend, refer to paragraph 1.3.)

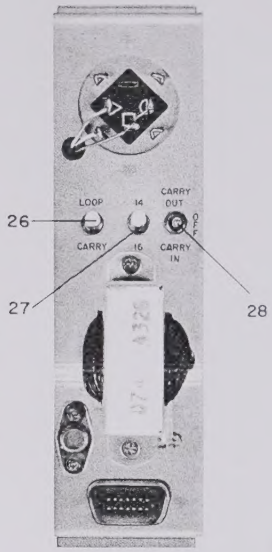


Figure 1-3. Rear view of the Type 1395-P6 Word Generator.

TABLE 1-1
CONTROLS AND CONNECTORS

Reference	*Name*	*Type*	*Function*
1 through 16	none	Switches*	Determine whether a bit is 1 (output pulse exists at WORD OUT terminal) or 0 (no output pulse). A 1 is generated when the switch handle points toward its number. Positions 15 and 16 (red) are inoperative when the module is set for 14-bit capacity.
17	SET 0	Push button	Clears all pulses from the Word Generator.
18	SET 1	Push button	Inserts a single starting pulse into the Word Generator.
19 20	CLOCK IN	Jacks	Timing pulse input to control bit rate. Insulated terminal is high, uninsulated terminal is ground.
21 22	CRO SYNC	Jacks	Output pulse to trigger oscilloscope at start of word. Insulated terminal is high, uninsulated is ground.
23 24	WORD OUT	Jacks	Output pulses in binary pattern. Insulated terminal is high, uninsulated terminal is ground.
25	none	Aluminum disk	Write-on tab for identification of module in large set-ups.
26	LOOP-CARRY	Switch	Determines whether module is cascaded with others or self-contained.
27	14 - 16	Switch	Determines whether module has 14- or 16-bit capacity.
28	CARRY OUT – CARRY IN	Switch	Determines function of first and last modules in a cascaded sequence.

* Switches at red-engraved numbers (15 - 16) are referred to as "red" switches; the others (1 - 14) are at white-engraved numbers, and referred to as "white" switches.

The output pulses from the Word Generator are trigger signals designed to operate other 1395 Series modules, such as the Type 1395-P2 Pulse/Delay Unit. Each Word Generator also provides a synchronizing pulse coincident with the time when a word starts, irrespective of the pattern of the binary word.

The circuits in the Word Generator consist of the following basic parts:

a. a ring counter, which may be broken open for splicing in other rings to provide more bits,

b. input and output pulse-shaping circuits,

c. reset and clear circuits.

These circuits are described in Section 3 of this instruction book.

1.3 CONTROLS AND CONNECTORS.

The controls and connection points required for operation of the Word Generator in 14- and 16-bit modes are identified in Table 1-1. Figure 1-2 shows front-panel controls; Figure 1-3 shows rear-panel controls.

For bit capacities other than 14 and 16, a patch-cord connection on the etched boards is required. This application is described in paragraph 2.3.3.

1.4 STORAGE OF SPARE MODULES.

The modules of the 1395 family are shipped sandwiched between sheets of plastic foam. These sheets of foam fit cross-wise in a standard filing cabinet, as do the manila folders commonly used for 8-1/2 by 11 papers. Slip unused modules between foam sheets and store them in a file drawer. They will remain clean and protected, and positioned so that the module type is instantly recognized. If the foam sheets loosen from frequent handling, an elastic band will hold them in place.

SECTION 2

OPERATING PROCEDURE

TURN OFF THE POWER BEFORE YOU INSERT OR REMOVE ANY MODULE!

2.1 POWER CONNECTIONS.

The Type 1395-P6 Word Generator produces most of its own power through a self-contained regulated power supply that uses 6.3 volts ac as the primary source of energy. A source of +15 volts at 5 mA is also required. Both these voltages are furnished by the Type 1395-A Modular Pulse Generator. The small raised guides on the floor of the internal cavity define seven positions into which the Word Generator can be placed. The user's convenience and required interconnections with other 1395 Series modules are the sole factors that determine the position to select.

To connect to the Type 1395-A power supplies, simply slide the Word Generator into the Modular Pulse Generator. When the Word Generator is nearly fully inserted, make sure that the power connectors are mated, then push it in firmly and fasten the thumbscrew at the bottom edge of the panel.

Operation of a Word Generator outside the Type 1395-A main frame is not recommended. The exposed circuitry is vulnerable to damage. External connection requires an interconnecting cord between the Word Generator and the Type 1395-A main frame. Pulses as well as power travel through this cord, so crosstalk and stray capacitance are likely to cause unsatisfactory performance. If external connection between the Word Generator and the frame is unavoidable, use an Amphenol Number 57-20140 connector or the equivalent.

2.2 INTERCONNECTION WITH OTHER 1395 SERIES MODULES.

2.2.1 GENERAL.

Inasmuch as the Type 1395-A Modular Pulse Generator permits as much versatility as possible in assembly of pulse-generating equipment, this book cannot possibly cover all interconnections, or even a generous assortment of them. However, some samples are described in the following paragraphs.

2.2.2 KEEPING TRACK OF THE MODULES.

The aluminum-foil tab (25 in Figure 1-1) has a slightly roughened surface to take marks from an ordinary lead pencil. When a Type 1395 system involves many modules, it is handy to number the individual plug-ins on both an interconnection sketch and these aluminum tabs. In the examples in paragraphs 2.2.5 through 2.2.7, this practice is very helpful.

2.2.3 PRELIMINARY CONSIDERATIONS.

Remember that the Word Generator is helpless by itself. It must receive clock pulses from outside. These pulses must be between 10 and 20 volts in amplitude, and between 75 and 150 nanoseconds in duration. Remember also that the signal from the WORD OUT terminal is a set of pulses designed to trig

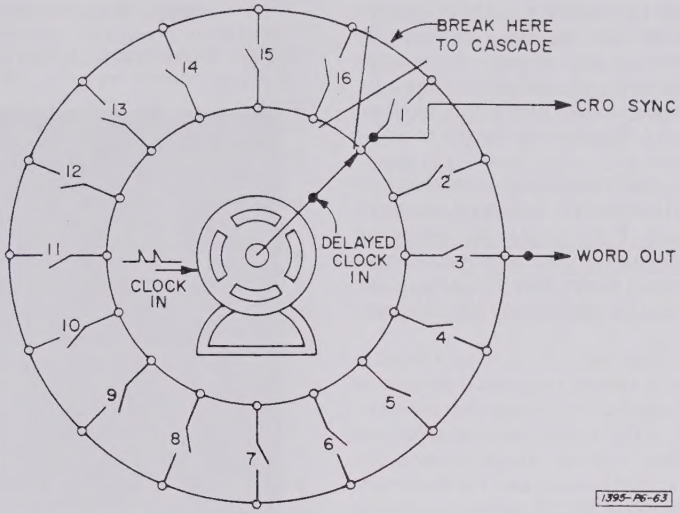


Figure 2-1. Basic concept of the Type 1395-P6 Word Generator.

other modules. Unless the 10-to-20-volt, 75-to-150-nanosecond pulses happen to fit a particular application, the Word Generator output must be used to drive a Type 1395-P2 Pulse/Delay Unit and/or a Type 1395-P3 Pulse Shaper.

Figure 2-1 gives a general idea of how the Type 1395-P6 Word Generator works. Imagine a stepper motor driving a commutator. This motor shifts one step every time a CLOCK IN pulse arrives. After enough delay to let the commutator settle into its new position, the clock pulse is applied to the commutator itself. Every time the commutator is in position 1, a pulse comes out on the CRO SYNC line, whether switch 1 is open or closed.

If any of the switches 1 through 16 is closed, the corresponding pulse will flow out of the WORD OUT terminal. Thus, any binary word with 16 bits can be produced with the system shown in Figure 2-1. For greater bit capacity, the ring in Figure 2-1 is broken open at the big X and another open ring spliced to it.

2.2.4 THE BASIC 16-BIT WORD GENERATOR.

Figure 2-2 shows the simplest configuration with a Type 1395-P6 Word Generator. In this example, the Word Generator is driven by a Type 1395-P1 PRF Unit and its output, in turn, drives a Type 1395-P2 Pulse/Delay Unit. For purposes of illustration, the pulse repetition frequency is 100 kc/s and the final output pulses from the Pulse/Delay Unit are positive-going and 2 microseconds in duration.

The output energy behind the WORD OUT terminal comes from a current source, a grounded-base transistor. This source was chosen so that many units can be cascaded by simply joining all the WORD OUT terminals with patch cords. However, the current must have a place to flow, and therefore an external load is needed. Note that one load will serve from one to seven Word Generators. The value of the load is not critical: 500 to 1000 ohms is suggested.

The back-panel switch settings (not shown in Figure 2-2) are as follows: the 14 - 16 switch is set

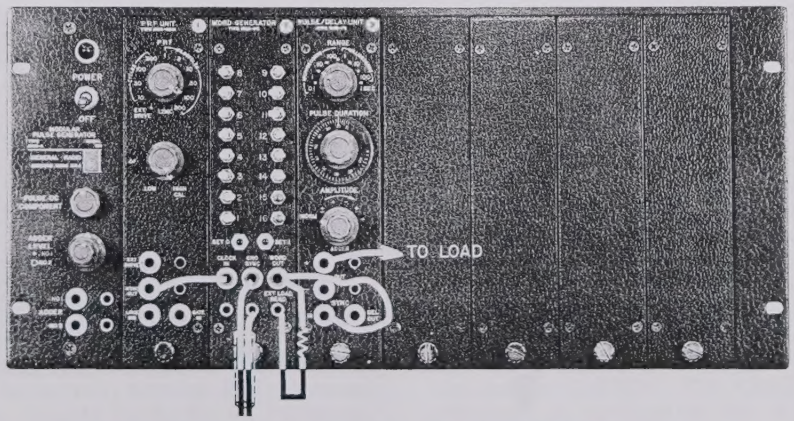


Figure 2-2. Interconnections for a basic 16-bit Word Generator.

to 16 for 16-bit capacity; the LOOP - CARRY switch is set to LOOP so that after bit 16, bit 1 repeats (in terms of Figure 2-1, there is no opening at X); the CARRY OUT - CARRY IN switch is set to OFF (middle position) because the sequence of bits is not carried from one unit to another. The entire word is self-contained in one module.

The pattern set by the front-panel switches is entirely at the user's pleasure. For example, we have used 1100000001100000. A 1 is produced when the switch handle points towards its own number. Thus, numbers 1 to 8 give 1's when their handles are to the right; numbers 9 to 16 give 1's when their handles are to the left.

When the power is first turned on, it is a matter of luck which, if any, stages in the ring have pulses in them. In the analogy of Figure 2-1, during the moment of turn-on, there may be extra commutators attached to the motor. If the pulses are all swept around the ring, each closed switch will give several 1's for every sixteen CLOCK IN pulses. The SET 1 button removes all pulses in the ring save one. The SET 0 button removes all pulses in the ring, and leaves the Word Generator inoperative. Thus, the SET 0 and SET 1 buttons can be used as an on-off control, allowing binary sequences to be started or stopped without turning off the power on the Type 1395-A main frame. (The SET 0 feature is explained further in paragraph 2.2.5.)

The signal to the oscilloscope is essential to keep track of the binary patterns. If the oscilloscope is synchronized from any other place, it will lock on pulses within the word, rather than on the entire word. Every time the binary pattern changes, the oscilloscope is likely to lock at a different point. The effect is annoying almost beyond description, and gives the impression that the Word Generator is out of order. Be sure to synchronize an oscilloscope only from the CRO SYNC terminal. Use a coaxial patch cord because the pulse signals running along open wire would introduce spurious pips and wiggles at other points in the 1395 system.

Figure 2-3 shows three of the pulse patterns available from the set-up in Figure 2-2. The top pattern, 1100000001100000, corresponds to the switch

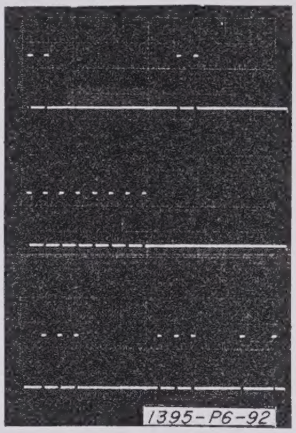


Figure 2-3. Sample patterns from the circuit configuration in Figure 2-2. Top pattern is 1100000001100000, with the switches set as shown; center pattern is 1111111100000000; bottom pattern is 0111000011100101.

settings in the illustration. The center pattern is 1111111100000000, and the bottom binary pattern is 0111000011100101. There are 2^{16} patterns available, or somewhat over 64,000.

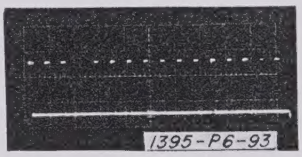


Figure 2-4. An example of improper oscilloscope synchronization. The pattern is 0111000011100101 (bottom pattern in Figure 2-3) photographed with internal oscilloscope synchronization.

As an example of what happens when the oscilloscope synchronizing signal is derived from a place other than the CRO SYNC terminal, refer to Figure 2-4. This shows the pattern 0111000011100101 (bottom pattern in Figure 2-3) taken with internal oscilloscope synchronization.

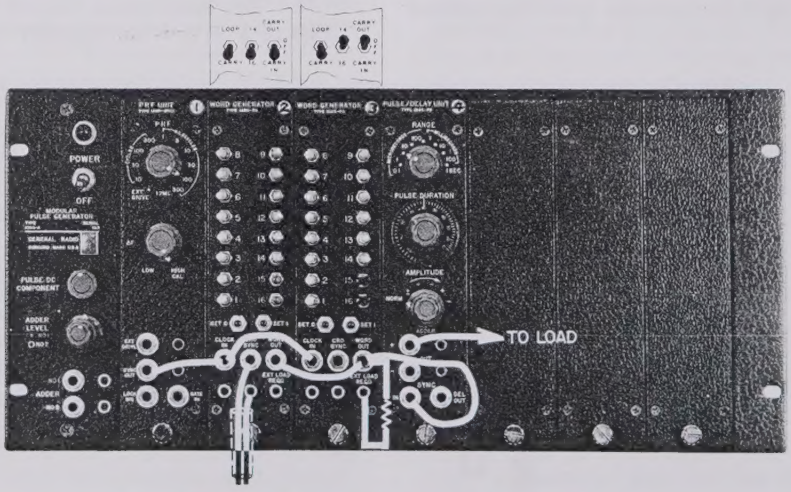


Figure 2-5. Two Word Generators cascaded for a 30-bit word.

2.2.5 TWO CASCADED WORD GENERATORS.

The next step in complexity of interconnections is two units in cascade for 28-, 30-, or 32-bit capacity. This connection is shown in Figure 2-5. Sketches above the Word Generators (modules 2 and 3) show back-panel switching. Cascaded Word Generators must be in adjacent plug-in slots.

When two or more Word Generators are cascaded to generate words (not for scaling as described in paragraph 2.2.7), all the LOOP - CARRY switches (26 in Figure 1-3) must be set to CARRY. The generator farthest to the right, as you face the front panel, must be set to CARRY OUT (switch 28 in Figure 1-2). The generator farthest to the left must be set to CARRY IN (switch 28 in Figure 1-2). The 14 - 16 switches have nothing to do with cascading, but simply determine the bit capacity of the individual Word Generators. For illustration, module number 2 (on aluminum tab) is set for 16 bits and module 3 is set for 14 bits. The two Word Generators add their number of bits for a total capacity of 30 bits.

Note closely the interconnecting cables at the front of the instrument. All CLOCK IN terminals are in parallel. All WORD OUT terminals are in parallel. There is only one load resistor for all the WORD OUT terminals. The coaxial cable from the CRO SYNC terminal connects to the oscilloscope. Either CRO SYNC terminal can be used, but the left-hand Word Generator module is usually thought of as the starting point for the pattern, so we chose this module as the source for oscilloscope synchronization.

On module number 3 of Figure 2-5, switches 15 and 16 are X'd over to indicate that they are not operable. After the 14th switch is visited by the circulating pulse, the pulse is carried out of unit 3 (note setting of CARRY IN - CARRY OUT switch), and carried in to unit 2. It makes no difference how switches 15 and 16 on unit 3 are set, because no pulse ever reaches them. In the actual Word Generator, switches 15 and 16 are marked red as a reminder that they are not necessarily working.

In cascaded operation when the SET 1 button is pressed, a pulse lasting about 50 milliseconds is produced. As long as this pulse endures, the segment of the ring behind switch 1 stands waiting to capture the pulse commutated around the ring by the CLOCK IN pulses. If the SET 1 button on module 2 (Figure 2-5) is pressed, and the frequency of the CLOCK IN pulses is 100 kc/s (set by module 1), then module 2 will wait for 5000 pulse periods to capture the commutating pulse (5000 100-kc pulses occur in 50 milliseconds). No matter where the traveling pulse is when the SET 1 button is pressed, it will return to switch 1 of module 2 long before the 50 milliseconds are up. At worst, it will have to shift 29 positions, and there will be 5000 CLOCK IN pulses to make it do so.

Suppose, however, that the clock frequency is low, say 1 c/s. It will take between 1 and 29 seconds after the SET 1 button is pressed for the commutating pulse to return to switch 1 of module 2. The 50-millisecond capture time is useless. Now the SET 0 buttons come into their own. Simply press the SET 0 button on every Word Generator, so that there is no commutating pulse anywhere in the system. Next, press a SET 1 button on any one Word Generator module. This inserts a single commutating pulse into the ring and holds it at Switch 1. The length of capture time does not matter since there is no traveling pulse to capture.

Figure 2-6 shows a few of the patterns produced with the set-up shown in Figure 2-5. The top oscillogram shows a single 30-bit word. The binary pattern is 10011100001111100000011111100. The center picture shows how the 30-bit capability is divided by repeating the same pattern twice, i.e., two 15-bit words of 111001111111110. The bottom photograph illustrates five 6-bit words, each 110010.

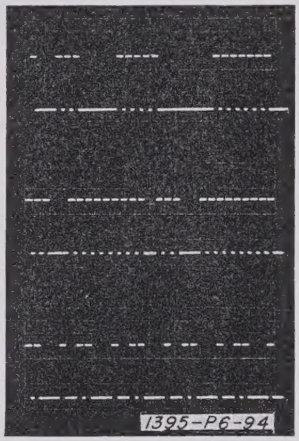


Figure 2-6. A few of the patterns produced by the circuit configuration shown in Figure 2-5. The top pattern is a single 30-bit word; center, two 15-bit words; bottom, five 6-bit words.

The words need not all be alike when high bit capacity is divided among several words. For example, five different 6-bit words can be produced from 30 available bits to check the response of equipment under test to five different conditions.

2.2.6 THREE OR MORE CASCADED GENERATORS.

If three or more Word Generators are cascaded, the CARRY OUT - CARRY IN switches must be engaged only on the modules at the left-hand and right-hand ends. An example is shown in Figure 2-7. Here four Word Generators are cascaded for a bit capability of 60 (two 14-bit modules and two 16-bit modules). The Word Generator on the extreme right is the end of the ring; its last pulse must be carried out and sent to the beginning. The unit on the extreme left is the start of the ring; the pulse that approaches it from unit 5 must be carried in. Hence the switch on unit 2 is set to CARRY IN and the switch on unit 5 to CARRY OUT.

The units in the middle (numbers 3 and 4) also generate and receive carry pulses. Their carry pulses are transmitted by intermodule wiring in the Type 1395-A main frame when the LOOP - CARRY switches are set to CARRY. The CARRY OUT - CARRY IN switches on modules in the middle of a ring must always be set to OFF.

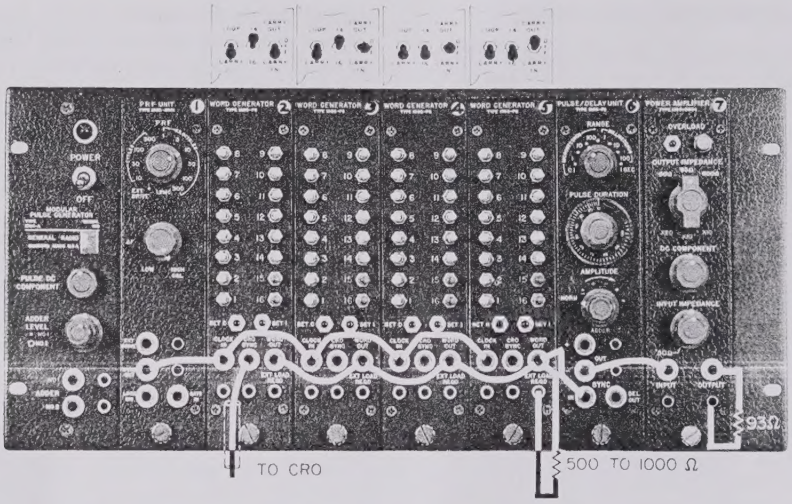


Figure 2-7. Four Word Generators cascaded for 60-bit capacity.

Note that on units 2 and 5, the LOOP - CARRY switches are set to CARRY, just as they are on the middle modules, numbers 3 and 4. When Word Generators are connected in cascade, the LOOP - CARRY switch on every module must be set to CARRY, regardless of the settings of the CARRY OUT - CARRY IN switches.

Figure 2-7 shows four cascaded Word Generators used with a Type 1395-P4 Power Amplifier. The Power Amplifier is used when more power is required than is available from a Type 1395-P2 Pulse/Delay Unit. The circuit arrangement in Figure 2-7 provides amplified negative-going pulses of 10-microsecond duration into a 93-ohm load. The bit repetition rate is 10 kc/s.

2.2.7 THE TYPE 1395-P6 AS A SCALER.

The Word Generator can be used as a scaler when the WORD OUT connection of one Word Generator serves as the CLOCK IN pulse to the next generator. In this type of service, the Word Generators are not usually cascaded as described in the preceding paragraphs. (An application involving both scaling and cascading is described in paragraph 2.3.4.) The carry feature is seldom employed in scaler applications.

Figure 2-8 shows two Word Generators connected to scale by a factor of 28 (4 x 7). For every four pulses that come from module 1, module 2 gives an output. For every seven pulses from module 2, module 4 gives

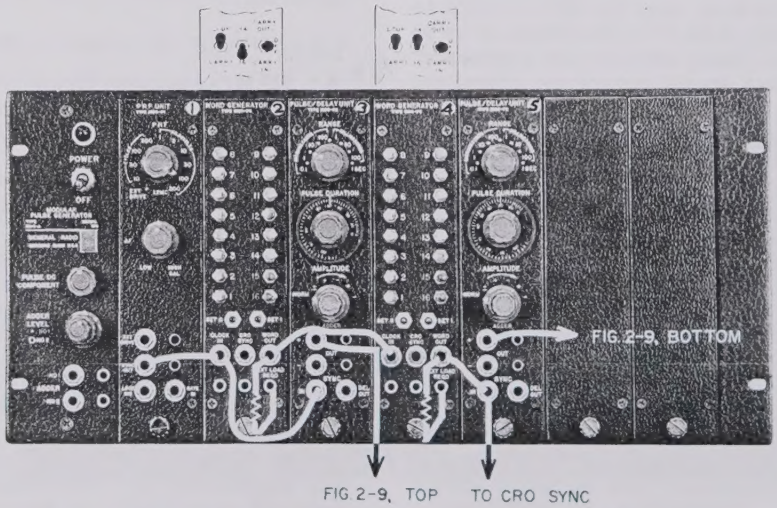


Figure 2-8. Two Word Generators connected as a scale-of-28 divider.

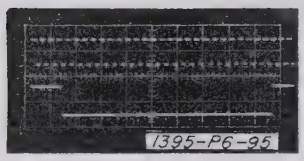


Figure 2-9. Illustration of division by 28 with the scaler shown in Figure 2-8.

an output. Plug-in modules 3 and 5 provide sufficient duration so that the pulses will show in photographs. The results are shown in Figure 2-9. The top trace has 28 pulses for every pulse on the bottom trace.

In this simple case of scaling by 28, the 28 ratio could have been achieved by cascading two 14-bit modules. Suppose, however, that we turn off all bit switches in Figure 2-8 except 16 in module 2 and 14 in module 4. We now have a ratio of 16 x 14 = 224. This ratio cannot be achieved by cascading even a whole rack full of Word Generators.

In scaling service, each Word Generator works independently. Therefore, each unit must have its own load resistor, and must be started separately by pressing its SET 1 button.

2.3 OPERATING TECHNIQUES.

2.3.1 GENERAL.

The descriptions of interconnections in Section 2.2 also contain information on operating procedure. Be sure that you understand the material in Section 2.2 before you proceed to paragraphs 2.3.2 through 2.3.4.

2.3.2 THE SET 0 AND SET 1 BUTTONS.

With a single Word Generator operating as a self-contained unit in the looped mode, simply press the SET 1 button to put the Word Generator in operation.

When several Word Generators are cascaded, the effects of the pushbuttons are functions of the total bit capacity and the PRF of the driving clock. Any SET 1 button will put the cascaded set of Word Generators into proper operation if the total bit capacity is less than the quantity 0.05 x PRF. This is because the SET 1 pushbutton triggers a resetting pulse that lasts for approximately 50 milliseconds, or for a number of bit times equal to the CLOCK IN frequency times the 50 milliseconds.

Figure 2-10 shows under what circumstances it is sufficient simply to push the SET 1 button. When the bit rate intersects the number of cascaded bits in the lower section of the chart, it is sufficient simply to push a SET 1 button. If the intersection is in the upper section, the SET 0 buttons on all the units must be pressed before a SET 1 button is pressed.

At a bit rate higher than 2.2 kc/s, as many as 112 bits will be reset in the 50-ms reset time, and the capacity of the main frame with seven Word Generators is 112 bits. When the number of cascaded bits is lower than 16, only one module should be in use. With only one module, the SET 1 button always sets up proper operation because this button both clears the module and inserts a single commutating pulse.

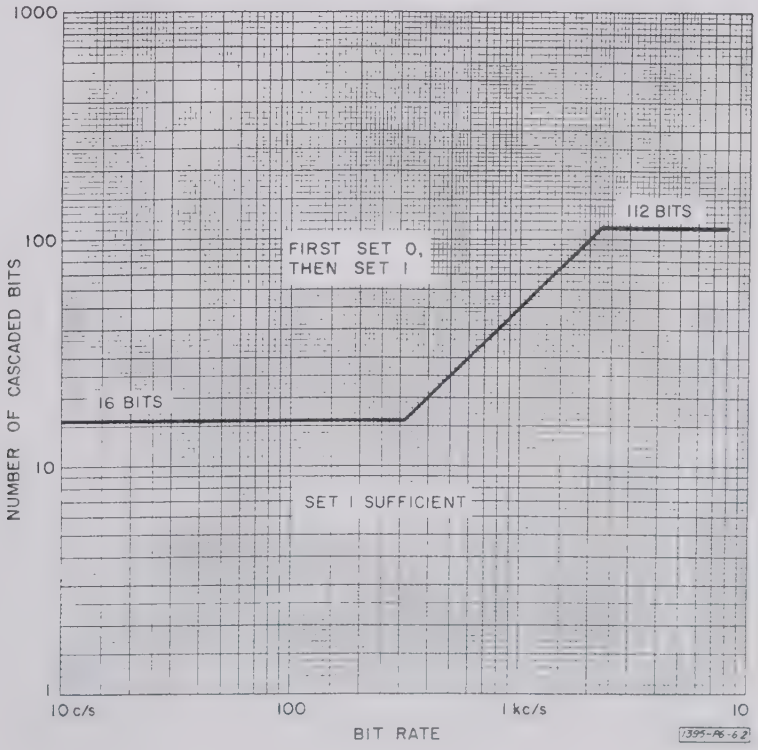


Figure 2-10. Relation between bit rate and bit capacity to determine whether a Word Generator must be zero-set before press the SET 1 button.

If it is necessary to push any SET 0 button, it is necessary to push them all. There is no way of telling which modules hold traveling pulses after the turn-on transient. With five 16-bit modules (total 80-bit capacity) operating at a PRF rate of one bit per second, it will take 80 seconds to trap and kill all commutating pulses if you simply hold down one of the SET 0 buttons. If you push all the SET 0 buttons, you will catch the pulses wherever they are.

It is possible that pulses might hop from one module to the next just as you release the SET 0 button. In this case, all the commutating pulses left from the turn-on transient might not be cleared when the SET 0 buttons are pressed one at a time. The best solution is to push all (or as many as you can reach) SET 0 buttons at once.

Another way to ensure proper start-up is to disconnect the CLOCK IN pulses while you zero-set the Word Generator. The spurious commutating pulses will move from one module to another only in response to CLOCK IN pulses. The SET 0 button will kill all spurious pulses in its own module. If there are no CLOCK IN pulses, no additional spurious commutator pulses can enter as you release the button.

Remember the purpose of the SET 0 routine is to get rid of turn-on transient residual pulses. Once these pulses are eliminated, press only one SET 1 button.

No matter what the operating frequency and the bit capacity, no harm is done when the SET 0 buttons are pressed before a SET 1 button. If you follow this procedure, you should not have any difficulty starting a cascade of Word Generators.

2.3.3 CAPACITIES OTHER THAN 14 AND 16 BITS PER MODULE.

Certain bit capacities, such as 2, 4, 7, and 8, can be simulated by repetition of patterns on the 14 or 16 switches. Each Word Generator connected for 16-bit capacity can be regarded as eight 2-bit Word Generators when the switches are used in pairs: 1 - 2, 3 - 4, 5 - 6, 7 - 8, 9 - 10, 11 - 12, 13 - 14, 15 - 16. For 4-bit words, think of the switches as quads: 1-2-3-4, 5-6-7-8, 9-10-11-12, and 13-14-15-16. For 8-bit words use switches 1 through 8 for one word and switches 9 through 16 for another word. For 7-bit words, set the Word Generator for 14-bit capacity with the rear switch, and use panel switches 1 through 7 for one word, switches 8 through 14 for another.

Any bit capacity lower than 16 can be obtained by a simple change in the internal wiring, accomplished by a patch-cord connection and removal of a plug-in component.

To change the bit capacity, remove the screws that hold etched board No. 1395-0765, swing the board back, and locate anchor terminal AT207, which is a plug-in jack. A white wire with green tracer is plugged into AT207.

To obtain new bit capacities, make the wiring and component changes listed in Table 2-1. Component part locations are shown in Figures 4-3 and 4-4 at the rear of this manual. For capacities of 13 bits or fewer, it does not matter how the 14 - 16 switch on the rear panel is set.

For each modification listed in Table 2-1, a capacitor is unplugged and the white-green wire inserted at the proper point. No soldering is required.

TABLE 2-1
MODIFICATIONS FOR LOW BIT CAPACITIES

Capacity	*Unplug Component*	*Board Location of Components*	*Connect White-Green Wire to*
15 bits	C216	1395-0765	emitter of Q215 Be sure 14 - 16 switch is set to 16.
14 bits	Simply set rear-panel 14 - 16 switch to 14.		
13 bits	C212	1395-0765	emitter of Q211
12 bits	C210	1395-0765	emitter of Q209
11 bits	C208	1395-0765	emitter of Q207
10 bits	C206	1395-0765	emitter of Q205
9 bits	C204	1395-0765	emitter of Q203
8 bits	C202	1395-0765	jack that joins AT202
7 bits	C122	1395-0760	emitter of Q122
6 bits	C120	1395-0760	emitter of Q120
5 bits	C118	1395-0760	emitter of Q118
4 bits	C116	1395-0760	emitter of Q116
3 bits	C114	1395-0760	emitter of Q114
2 bits	C112	1395-0760	emitter of Q112

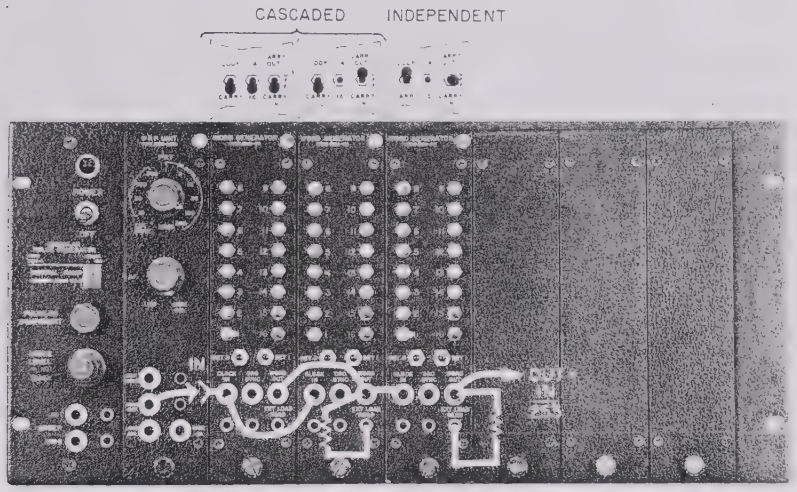


Figure 2-11. Three Word Generators connected to scale by 253. The first two Word Generators are cascaded, the third is independent.

If it appears that some component or wire must be soldered, check very carefully against the etched-board drawings in Figures 4-3 and 4-4: you are about to make a mistake!

If a module is modified, we suggest that it be marked in some way. The number of active positions can be written on the aluminum tab on the front panel, or the inactive switch handles can be stuck together with a strip of masking tape. It is also a good idea to tape the unplugged capacitor to the back of the module so it will not be lost.

These modifications in bit capacity do not change any of the other operating features of the modules (except that the 14 - 16 switch is not effective with a bit capacity below 14). The LOOP - CARRY and CARRY OUT - CARRY IN switches are used exactly as before. Interconnections for cascading and scaling are identical to those described in Section 2.2.

A modified module and a standard module (or several of each) can be cascaded to obtain almost any total number of bits. Usually there will be several ways to do this, and the choice is apt to be made by balancing convenience against cost. For example, suppose 27 bits are required to simulate three 9-bit words. A 16-bit module and an 11-bit module can be cascaded for the total capacity, which results in good economy of modules but requires that the user remember switches 1 through 9 on the first module form one word, switch 10 on the first module through switch 2 on the second module make the next word, and switches 3 through 11 on the second module give the third word. Furthermore, switches 12 through 16 on the second module do nothing. One alternative route to three 9-bit words is three modules, each set for nine bits, in cascade. Each module is then an independent word and it is easier to keep track of what one is doing. The penalty is that more equipment is required.

Certain bit capacities take a little extra planning to set up. For example, there is no patch-plug arrangement to get 1-bit capacity. Therefore, a total capacity of 17 bits cannot be achieved by 16 cascaded with 1. Instead, use 14 plus 3.

2.3.4 SCALING.

The scaling operation is a process of counting down or dividing. The result can be achieved by driving one Word Generator from another, each generator representing one factor in the divisor. For example, suppose you wish to scale (or divide) by 48. Since 48 is equal to $2^4 \times 3$, five modules can be used, each of the first four set to scale by 2 and the fifth module arrange to scale by 3 (bit capacities modified as described in paragraph 2.3.3). However, 48 also equals 16 x 3, which means we can use one standard module with its full 16-bit capacity and one module modified to scale by 3. When you set up scaling operations, always look for the scheme that uses the least equipment. Unlike binary words, scaling factors are rarely changed during a given experiment, so there is no merit in using a different module for each factor.

In paragraph 2.2.7, we noted that Word Generators are rarely cascaded for scaler service. But consider the unusual requirement of scaling by 253. 253 equals 23 x 11, a pair of prime numbers. Furthermore, 23 is greater than the capacity of one module.

To solve this problem we cascade two modules for a capacity of 23, and use the output of the cascaded pair to drive a third module connected for 11-bit capacity. The 23-bit capacity can be obtained in many ways. On the assumption it is handier to modify one module than two, leave one module set for 16 bits and change the second module to 7 bits.

The system set-up for scaling by 253 is shown in Figure 2-11. Each aluminum tab is marked with the capacity of the Word Generator. Modules 16 and 7 are cascaded together to give 23 bits. Note that both LOOP - CARRY switches are set to CARRY. The module in the center, number 7, is set to CARRY OUT; number 16 must CARRY IN. The 14 - 16 switch on number 7 does not matter, because the portion of the ring beyond switch 7 is disabled.

Module 11 is an independent unit. It receives just one pulse from the 16-7 cascaded pair (note only

one front-panel switch in the 16-7 pair is on) for every 23 input pulses, and delivers one output for every 11 of these received pulses. Thus module 11 gives an output pulse for every 23 x 11 or 253 input pulses from the PRF Unit. Since module 11 operates with 11-bit capacity, the setting of its 14 - 16 switch is unimportant. Also, since it operates as a self-contained unit, the LOOP - CARRY switch is at LOOP, and the CARRY OUT - CARRY IN switch is OFF.

Scaling by large numbers is not always possible. It depends on the factors. For example, scaling by 961 could be set up with one cascade of 16 + 15 (31-bit capacity), driving a second cascade of 16 + 15 (31-bit capacity), giving a product of 31 x 31 or 961. But scaling by 226 is not possible with Word Generator modules because the factors of 226 are 2 and 113. 113 exceeds the bit capacity of an entire rack of seven Word Generators.

SECTION 3

PRINCIPLES OF OPERATION

3.1 GENERAL.

A simplified description of the operating principles is given in paragraph 2.2.3. The material in this section will be easier to follow if you are familiar with the material in paragraph 2.2.3.

Figure 3-1 is a block diagram of the Type 1395-P6 Word Generator. A single pulse travels around the commutator from position 1 to 16 and then back to 1. This is a single pulse only because the SET 1 pulse generator wipes out any other commutating pulses present after the turn-on transient and deliberately inserts only one pulse in the commutator.

The commutator is driven around by driver stages Q107 and Q201. For each CLOCK IN pulse, the commutating pulse is shifted one slot. Every time the commutating pulse comes to slot 1, a pulse is sent out through the oscilloscope synchronizing buffer, Q108. This pulse is connected to the external synchronizing terminal of an oscilloscope to make the oscilloscope synchronize with the word, rather than with individual pulses within the word.

When the commutating pulse arrives at a given slot in the commutator, it tries to go through the front-panel switch and up to the gate (Q103 - Q104). Whether or not it succeeds depends on the setting of the switch.

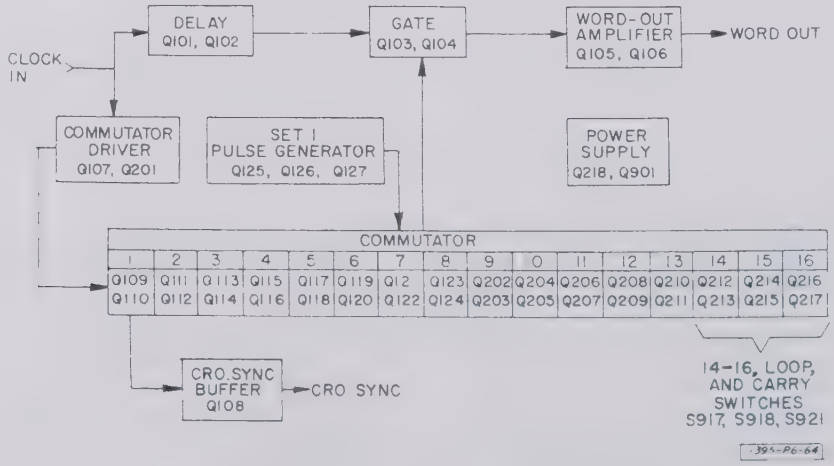

DELAY
Q101, Q102
GATE
Q103, Q104
WORD-OUT AMPLIFIER
Q105, Q106
WORD OUT
CLOCK IN
COMMUTATOR DRIVER
Q107, Q201
SET 1 PULSE GENERATOR
Q125, Q126, Q127
POWER SUPPLY
Q218, Q901
COMMUTATOR
1 2 3 4 5 6 7 8 9 0 11 12 13 14 15 16
Q109 Q111 Q113 Q115 Q117 Q119 Q12 Q123 Q202 Q204 Q206 Q208 Q210 Q212 Q214 Q216
Q110 Q112 Q114 Q116 Q118 Q120 Q122 Q124 Q203 Q205 Q207 Q209 Q211 Q213 Q215 Q217
CRO SYNC BUFFER Q108
CRO SYNC
14-16, LOOP, AND CARRY SWITCHES S917, S918, S921
395-P6-64

Figure 3-1. Block diagram of the Type 1395-P6 Word Generator.

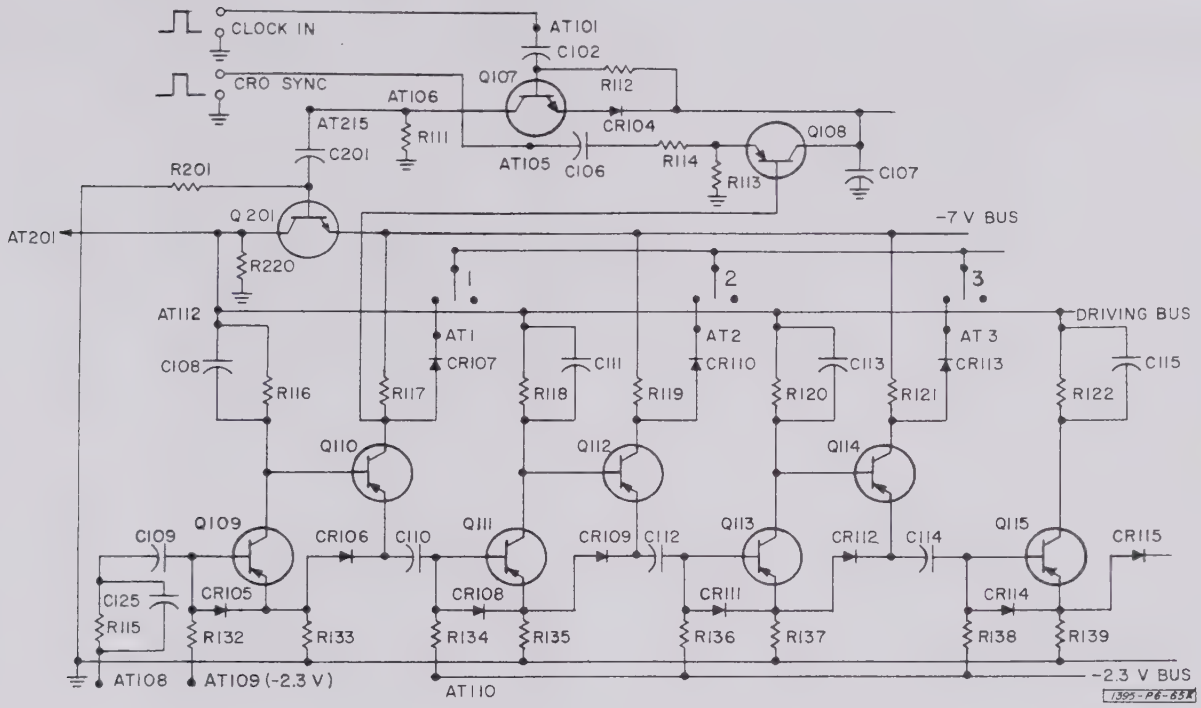


Figure 3-2. Three stages of the ring counter used in the Word Generator.

If the switch is closed, the commutating pulse enables the gate. A second pulse derived from the CLOCK IN source then passes through the gate and is amplified and shaped in the word-out amplifier (Q105 - Q106). The gated pulse is delayed 150 nanoseconds to allow 100-nanosecond transients that occur whenever the commutator is switched to decay.

3.2 THE COMMUTATOR.

The commutator is a ring counter that steps one position for every CLOCK IN pulse. A portion of this ring is shown in Figure 3-2.

Suppose transistors Q110, Q111, Q113, and Q115 are conducting and that Q109, Q112, and Q114 are off. Let a CLOCK IN pulse arrive at the CLOCK IN terminals. This pulse is inverted by Q107 and becomes a negative pulse at AT106. Q201 is ordinarily on since a base current of about 3.5 mA is injected into Q201 via R201. When the negative pulse appears at AT106, Q201 is turned off momentarily, and the voltage at R220 (AT201 and AT112) moves from about -6.8 volts to 0.

Now we will observe the consequences of this change in potential along the driving bus. Consider simultaneously the stages of the ring involving Q109, Q110, Q111, and Q112. Q110 is on and Q109 is off prior to the driving pulse. The IR drop across R133 gives a voltage of about -2.7 volts at the top of R133. The positive-going pulse on the driving bus turns Q110 off, but a little current flows still through R133, now from the emitter of Q109 to the base of Q109 and back through R132 to the -2.3-volt bus. As a result, the potential at the top of R133 is changed from -2.7 volts to about -0.1 volt, a rise in potential of about 2.6 volts. This rise is transmitted through CR106 and C110 to the base of Q111. At this moment: a) Q109 is passing current from emitter to base; b) Q110 is off; c) the base of Q111 is positive; and d) Q112 is off.

Now, remove the driving pulse. The voltage on the driving bus drops again to -6.8 volts. Q109 is already passing current, and as soon as its collector tries to drop toward the -6.8-volt level of the driving bus, this transistor changes from a conducting emitter-base diode to a saturated switch. The IR drop across R133 now becomes about -0.55 volt, and the collector of Q109 will not be very different because the transistor is saturated. Assume the collector potential of Q109 is -0.55 volt. This is also the base voltage on Q110. If Q110 were to conduct, its emitter current would have to flow through CR106. But CR106 is a silicon diode, chosen specifically to hold Q110 off at this time. This diode acts like a battery of about 0.7

volt, so that if current were to flow through CR106, the emitter of Q110 would be about 0.7 volt negative relative to the emitter of Q109, hence 0.7 volt negative relative to its own base. Since this is impossible, Q110 will be off.

Because of the voltage rise applied to the base of Q111 through C110, Q111 will not conduct. The negative voltage on the driving bus draws current out of the base of Q112 through R118, and so Q112 comes on. There is sufficient IR drop in R135 to keep Q111 biased off. Conduction has switched from Q110 to Q112.

Next, see what happens to stage 2 (Q113 and Q114), which typifies the action in all other ring stages. Q114 is off, and Q113 is on just before the pulse is applied to the driving bus. Therefore, current is flowing up R137 through the Q113 emitter, and the voltage at the top of R137 remains at about -0.55 volt. The collector of Q113 is at nearly the same voltage, since Q113 is driven to saturation by base current pulled down through R136. When the top of R120 goes from -6.8 volts to 0 volts, both the collector of Q113 and the base of Q114 rise in potential (momentarily a large rise, since the voltage across C113 cannot change instantaneously) and would ultimately be at 0 volts if the driving-bus pulse lasted more than a few hundred nanoseconds. If the base of Q114 goes more positive, nothing happens because Q114 is already off. While the collector of Q113 is at 0 volts, current coming up through R137 will no longer flow through the collector, but will flow into the base and return to the -2.3-volt bus through R136. Note that Q113 is thus predisposed to be on, and will resume conducting as soon as its collector returns from 0 to -6.8 volts.

Therefore, nothing happens to transistor pair Q113-Q114 as a result of the driving-bus pulse.

The net result is that a pulse on the driving bus transfers conduction from one even-numbered transistor to the next even-numbered transistor. (These are even-numbered transistors in the 100 series on board number 1395-0760; on board number 1395-0765, comparable transistors in the 200 series are odd-numbered.) If the initial premise, namely that only one even-numbered transistor is on, can be satisfied, then only one pulse will sweep around the commutator at any one time.

3.3 THE SET 0 – SET 1 SYSTEM.

To establish the initial conditions of only one even-numbered transistor (in this example, Q110) conducting, we use the circuit shown in Figure 3-3. Suppose that Q127 were removed. The potential at AT203 and AT110 would then be -7 volts and current would be drawn through R134, R136, etc., (see Figure 3-2) turning on the odd-numbered transistors (Q111, Q113, etc). However, AT109 would be at ground potential, so no current could flow in Q109 because such current would send the emitter negative relative to the base which stops current flow. On the other hand, Q110 will be turned on by base current drawn through R116 (see Figure 3-2). Therefore, when Q127 is removed or turned off, Q110 conducts and all other even-numbered transistors are off.

Q127 is controlled by the one-shot generator consisting of Q125 and Q126. Specifically, Q126 drives Q127. Q127 acts as a switch. When Q126 is off, current is drawn through the path R202 to the emitter of Q127 to the base of Q127 to R158 to the -7-volt bus. This turns Q127 on. The voltage-divider action of R202 and R203 pegs the voltage on both the emitter and collector of Q127 at values very close to the -2.3 volts required for proper commutator action.

When the SET 1 button is pushed, a one-shot action takes place in Q125 and Q126 (refer to the simplified diagram in Figure 3-4). A positive pulse going through CR129 turns off transistor Q125. With this transistor off, the voltage divider consisting of R150, R151, and R157, biases Q126 so that heavy conduction starts and the potential at the bottom of R158 drops to 0. This causes the emitter of Q127 to go to 0 and thus turns Q109 off. Since Q127 is off, there is no longer an IR drop in R203 (save for the relatively small cur-

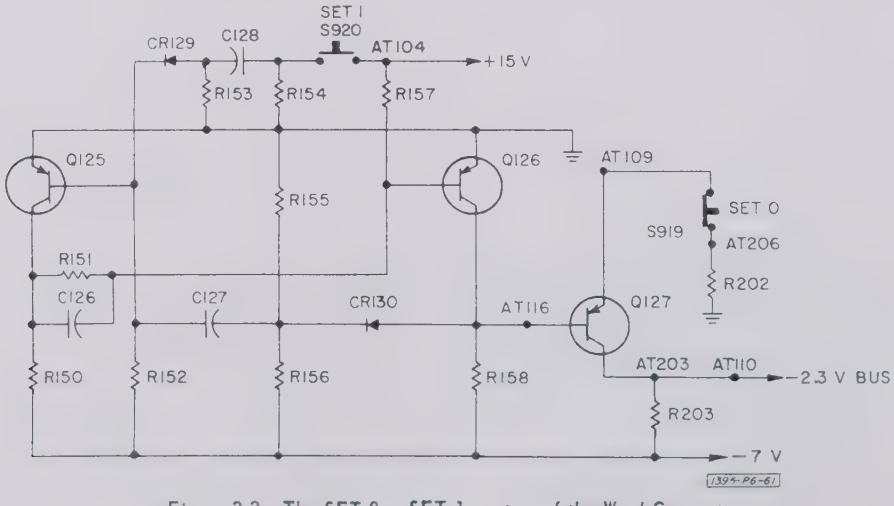


Figure 3-3. The SET 0 – SET 1 system of the Word Generator.

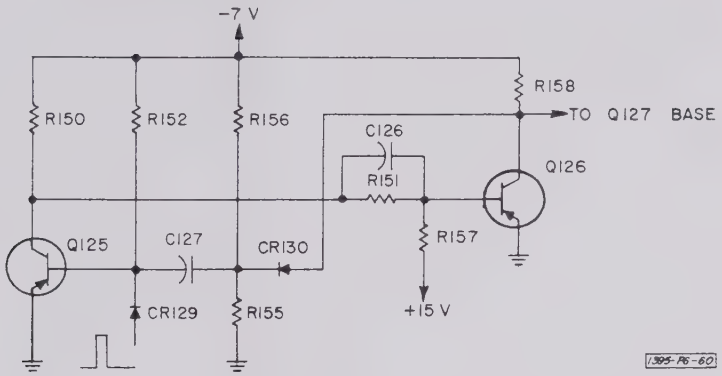


Figure 3-4. The one-shot reset generator in the SET 1 pulse generator.

rents that come to R203 through R134, R136, etc), and AT110 and AT203 go to about -7 volts. Thus, the single pulse is put into the commutator.

When R158 conducts heavily, the anode of CR130 is at ground, and CR130 is a closed circuit. Current flows up from ground through Q126 and CR130 (think of these two components as a closed switch shorting R155) and into C127. Before the SET 1 button was pressed, the junction of R155 and R156 was at -2.33 volts, and the base of silicon transistor Q125 was at about -0.7 volt. Therefore, C127 had a potential of about 1.6 volts across it, with the right-hand plate in Figure 3-4 negative. When R155 is shunted to ground, the potential across C127 shifts the base of Q125 up to +1.6 volts. Current starts flowing in the path ground-C127-R152. Presumably, C127 would eventually be fully charged to a new voltage with the base of Q125 at -7 volts. However, as this condition is approached, the base of Q125 goes negative below -0.7 volt, and Q125 turns on again, ending the charging time. The operating time of the one-shot action is therefore determined by the time required for the voltage at the base of Q125 to go from +1.6 volts to 0.7 volt on its way to -7 volts. This is a change of 2.3 volts out of a possible 8.6 volts, or a drop to about 73% of the 8.6-volt charging voltage. The change takes place in about 0.3 times the time constant. The time constant is R152 x C127 or 220 milliseconds, and so the one-shot pulse will last about 0.3 x 220 or 66 milliseconds. The actual time varies a little from one Word Generator to another because of slightly different threshold voltages in Q125. The nominal SET 1 pulse time is 50 milliseconds.

The SET 0 action is much simpler. Pushbutto switch S919 is opened, and the voltage-divider actio between R202 and R203 ceases. AT109 assumes potential of about -7 volts, as do terminals AT110 an AT203. All the odd-numbered commutator transistor are turned on, and no commutator pulse is stored i the ring. (These are odd-numbered transistors in th 100 series on board number 1395-0760. In the 20 series on board number 1395-0765, even-numbere transistors would be on.)

3.4 DELAY AND GATE.

The transients associated with a stepping actio in the commutator last about 100 nanoseconds. There fore, a delay of about 150 nanoseconds is provided b a delay line so that no output pulse will be generate until the commutator settles down. The delay line i driven by emitter follower Q101 and loaded by resisto R103 and the base of Q102. These components ar shown in Figure 4-5. Q102 is a second emitter fol lower that drives one terminal of the gate, namely th base of Q103. A pulse passed down the delay line i not able to go through the gate unless the potential o the base of Q104 (AT103) is positive relative to -7 volts This condition is realized only when a) any switc S901 through S916 is closed; and b) the transistor jus behind the closed switch is conducting. Thus the gat translates the position-time sequence in the commu tator to a timed-pattern sequence at the input to th word-out amplifier, Q105-Q106.

SECTION 4

SERVICE AND MAINTENANCE

4.1 WARRANTY.

We warrant that each new instrument sold by us is free from defects in material and workmanship, and that, properly used, it will perform in full accordance with applicable specifications for a period of two years after original shipment. Any instrument or component that is found within the two-year period not to meet these standards after examination by our factory, sales engineering office, or authorized repair agency personnel, will be repaired, or, at our option, replaced without charge, except for tubes or batteries that have given normal service.

4.2 SERVICE.

The two-year warranty stated above attests the quality of materials and workmanship in our products. When difficulties do occur, our service engineers will assist in any way possible. If the difficulty cannot be eliminated by the use of the following service instructions, please write or phone our Service Department (see rear cover), giving full information of the trouble and of steps taken to remedy it. Be sure to mention the serial and type numbers of the instrument.

Before returning an instrument to General Radio for service, please write to our Service Department or nearest sales engineering office, requesting a Returned Material Tag. Use of this tag will ensure proper handling and identification. For instruments not covered by the warranty, a purchase order should be forwarded to avoid unnecessary delay.

4.3 TROUBLE-SHOOTING.

4.3.1 PASSING THE BUCK.

The Type 1395-P6 Word Generator can give no output of its own accord. It responds only to trigger pulses applied to the CLOCK IN terminal. Therefore, be sure that pulses of the proper amplitude, duration, and polarity are being received. Before you conclude that the Word Generator is out of order, substitute CLOCK IN pulses from a different source, such as another Type 1395-P1 PRF Unit. Also check the Type 1395-A Modular Pulse Generator as described in paragraph 4.3.2. Don't forget to press the SET 1 button.

4.3.2 TROUBLE-SHOOTING IN THE TYPE 1395-A MODULAR PULSE GENERATOR.

Make sure that the Type 1395-A Modular Pulse Generator is turned on, and that the power-line frequency and voltage are correct. Be sure that the Type 1395-A Generator is wired properly for the applied voltage. Check the fuses in the generator.

Check the voltages at the connector on the Type 1395-A, especially at the connector to which the Word Generator is attached. Connector voltages are listed in Table 4-1.

4.3.3 TROUBLE-SHOOTING IN THE TYPE 1395-P6 WORD GENERATOR.

4.3.3.1 General. If the Word Generators are in a cascaded connection, be sure that the back panel switches are properly set. Every cascaded Word Generator must be set to CARRY. The right-hand one must be set to CARRY OUT, the left-hand one to CARRY IN, and the CARRY OUT - CARRY IN switches on all others must be OFF. Remember that in cascaded operation, all the Word Generators must be immediately adjacent to each other in the main frame.

If the bit capacity of a Word Generator is altered to something other than 14 or 16 bits with the patch-cord change described in paragraph 2.3.3, be sure the connections are correct. If a Word Generator that was once altered is now supposed to be working in 14 or 16 bits again, be sure that none of the plug-in capacitors has been forgotten, and that the white-green wire is back in AT207.

Don't forget that a load (500 to 1000 ohms is recommended) must be connected to the WORD OUT terminals.

TABLE 4-1
CONNECTOR VOLTAGES ON THE GENERATOR

Pin	*Voltage*	*Procedure When Voltage Is Incorrect*
1	+150	The +150-V level depends on the -150-V supply. First check the -150-V level at pin 2 (see below). When the -150-V level is correct, adjust the +150-V level with R536. If this does not correct the level, check tubes V501 and V503.
2	-150	Adjust R525. If this does not correct the -150-V level, check tubes V502, V505, V506, and V507.
3	Not Applicable	
4	Not Applicable	
5		Turn the ADDER controls on all modules to NORM. Set ADDER LEVEL NO. 2 fully clockwise. Measure the resistance between pin 5 and the ADDER NO. 2 output terminal with an ohmmeter. If this resistance is higher than 5 ohms, check for broken wires between the plug and printed board or a defective ADDER LEVEL NO. 2 potentiometer.
6, 13	6.3 V, 60 c/s, at -75 V dc	Check fuses. If the dc level differs by more than about 10% from -75 volts, suspect a cathode-filament short in V505 or V506, or one of the plug-ins.
7, 14	6.3 V, 60 c/s, at +50 V dc	Check fuses. If the dc level differs by more than about 10% from +50 volts, suspect a cathode-filament short in one of the plug-ins.
8	+15	This supply is not regulated and cannot furnish much current. A voltage between 12 and 18 volts is OK. If the voltage is less than 12 volts, look for excessive current in one of the modules. If a Pulse/Delay Unit is suspected, look for a shorted CR210.
9	Ground	Check continuity with an ohmmeter. If the resistance between pin 9 and chassis is more than 1 ohm, look for broken wires or cold solder joints.
10	0 to +20 V dc, variable	Turn the PULSE DC COMPONENT control back and forth. Voltage on pin 10 must vary at least from 0 to +20 volts, and will probably vary from -2 or -3 volts to +22 or more volts. If performance falls short of a variation from 0 to +20 volts, check V504 and Q501.
11	Not Applicable	
12		Turn the ADDER controls on all modules to NORM. Set the ADDER LEVEL NO. 1 fully clockwise. Measure the resistance between pin 12 and ADDER NO. 1 output terminal with an ohmmeter. If this resistance is greater than 5 ohms, check for broken wires between plug and printed board or defective ADDER LEVEL NO. 1 potentiometer.

If the checks in paragraphs 4.3.1 and 4.3.2 show that the difficulty is indeed in the Word Generator, test the -7-volt power supply as described in paragraph 4.3.3.2. If the difficulty is still not eliminated, find the description of the malfunction in Table 4-2, then follow the trouble-shooting procedure in the paragraph referenced in the table.

4.3.3.2 Power Supply. Remove all modules from the Type 1395-A Modular Pulse Generator main frame. Look into the cavity toward the fan on the rear wall. To the right of the fan near the top of the wall is an extension cord for operating modules outside the main frame. Remove this cord and connect the Word Generator to any socket you wish in the Type 1395-A. For locations of components, refer to Figures 4-4 and 4-5, which show the etched-board layouts.

With a dc voltmeter, measure the voltage between ground and anchor terminal AT107 on etched board No. 1395-0760. This voltage should be -7 volts. If it is not, insert a long, slim screw-driver through the hole near the back edge of board number 1395-0760 and adjust R239 for the proper voltage. If the voltage cannot be set to -7 volts, turn the module around and measure the voltage between AT212 and AT208 (positive lead to AT208) on board number 1395-0765. This voltage depends on the value of the ac power-line voltage, but should be approximately 13 volts dc. If it is much lower than this, say 11 volts or less, check the diodes CR226, CR227, CR228, and CR229. One or more may be defective, probably open. If the voltage between AT212 and AT208 is nearly 13 volts, the trouble is probably in CR230, Q901, or Q218.

If the voltage at AT212 or AT107 is at least -6 volts with respect to ground, it will be possible to test CR230. Connect a dc voltmeter between AT212 and AT211, with AT211 positive. The voltage must be 5.6 volts ±10%. If it is not, replace CR230.

If CR230 is all right, the most probable site of the trouble is Q901, the small, diamond-shaped transistor on the back panel. Be sure to insulate this transistor when it is replaced. If the metal mounting base of the transistor is grounded, almost double the proper voltage is applied to the other transistors in the circuit. If Q901 is all right, the trouble is a defective Q218 or possibly a leaky or shorted electrolytic capacitor in the power supply.

To see if excessive current is flowing in the circuit beyond the rectifiers, measure the current in the violet wires attached to AT208. The total current in both wires should be about 240 mA after the SET 1 button is pressed, and 230 mA after the SET 0 button is pressed. These wires may be unsoldered for the measurement, or a clip-on dc milliammeter can be used.

4.3.3.3 No Output from the CRO SYNC Terminal. When there is no output from the CRO SYNC terminal, set the Word Generator for 16-bit capacity and looped operation, any convenient CLOCK IN frequency, and

TABLE 4-2
LOCATING A MALFUNCTION

Symptom	*Note*	*Trouble-Shooting Procedure*
No output from CRO SYNC terminal	Correct output from WORD OUT terminal	paragraph 4.3.3.3
No output from WORD OUT terminal	Correct output from CRO SYNC terminal	paragraph 4.3.3.4
More pulses per word than called for by switch settings	Oscilloscope is correctly connected to CRO SYNC, but pattern has too many pulses	paragraph 4.3.3.5
Fewer pulses per word than called for by switch settings	Oscilloscope is correctly connected to CRO SYNC, but pattern has too few pulses	paragraph 4.3.3.6
Switch position is bypassed	Commutator pulse skips a switch position and apparently shortens the ring	paragraph 4.3.3.7
Single switch changes entire pattern	When the switch at a defective stage is turned on, pulses are added to the pattern. These remain even when switch is turned off.	paragraph 4.3.3.8
Module is entirely inoperative	First check input and connections as described in paragraphs 4.3.1 and 4.3.3.1	paragraph 4.3.3.9

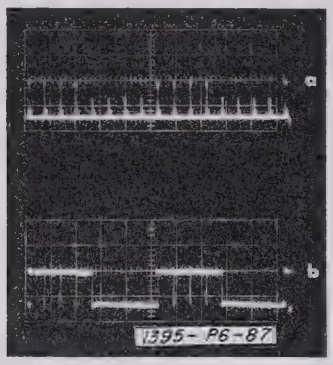
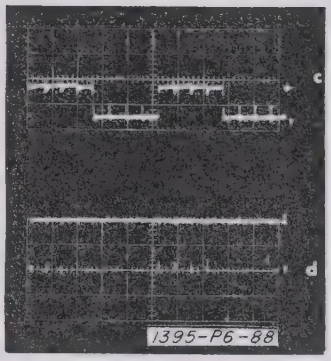


Figure 4-1. Waveforms at the following points in the gate circuit:
a. base of Q103 (The waveform at the emitter of Q103 is the same except it has two-thirds the amplitude.)
b. base of Q104
c. collector of Q103 and emitter of Q104
d. collector of Q104
For each waveform, vertical scale is 2 volts per major division with ground at the top grid line; horizontal scale, 5 μs per major division.



examine the waveform at the base of Q108. It should be a positive-going pulse, rising from -7 volts to approximately -4 volts. The pulse should last a span of time equal to one period of the driving clock frequency, and occur at 1/16 the rate of the CLOCK IN pulses. If this pulse is absent, but the output from the WORD OUT terminal is normal, Q108 is probably shorted to the -7-volt supply, and should be replaced. If the pulse is present at the base, check the emitter of Q108. If the pulse is present at the emitter but not at the CRO SYNC terminal, then R114 or C106 is open-circuited. If the pulse is not present at the emitter of Q108, then Q108 is open-circuited and should be replaced.

4.3.3.4 No Output from the WORD OUT Terminal. When the CRO SYNC output is operating properly but there is no output from the WORD OUT terminal, the trouble is in the delay, gate, or word-out amplifier circuits. The commutator and commutator driver are operating properly; otherwise the CRO SYNC output would not be normal.

With an oscilloscope, examine the waveform at the base of Q102. This waveform should consist of a continuous train of pulses at the same rate as the CLOCK IN pulses, and of similar shape. They will be approximately trapezoidal, positive-going from -7 volts to ground (or a trifle above ground), and about 100 nanoseconds in duration at the half-amplitude point. If such pulses are not present, then either the CLOCK IN pulses are of the wrong shape or amplitude, or, more probably, transistor Q101 or Q102 should be replaced. Check both of these transistors. A less likely, but possible, fault is a defective delay line DL101. With an ohmmeter, check for continuity through the delay line. The resistance should be between 30 and 40 ohms.

If the delay circuits (Q101, Q102, DL101) are good, investigate the gate circuit. Push the SET 0 button. With a dc voltmeter, check the voltages at the following points: base of Q104, -7 volts; collector of Q104, 0 volts; emitter of Q103, -7 volts. Since the gate should pass no current (except I_{CO} of the transistors) when the SET 0 button has been pushed, any deviation in these voltages means either a shorted transistor allowing unwanted current to flow, or an open-circuited resistor, establishing improper operating voltages. Test Q103, Q104, R105, R106, R107, and R108. If the voltage at the base of Q104 is near ground, C103 may be shorted.

Open-circuited transistors will pass this voltage test. To check further for open-circuited transistors, push the SET 1 button and apply a CLOCK IN signal. Set up a simple pattern, like 1111000011110000. Use a fairly high PRF rate, say a few hundred kc/s. With an oscilloscope, examine the waveform at the collector of Q104. This waveform should consist of a train of pulses in the sequence set. (In this example, the sequence is 1111000011110000.) The individual pulses are about 150 nanoseconds in duration and negative-going in polarity from 0 volts to about -4 volts. If such pulses are not present, the trouble is an open-circuit in Q103, Q104, R148, or the blue lead to AT103. Figure 4-1 shows normal waveforms at various points associated with the gate circuit.

If both the delay circuit and the gate circuit are normal, the word-out amplifier must be the seat of the trouble. Only four components (Q105, CR102, Q106, and CR103) are likely to be in difficulty. Q106 is the most probable because it occupies a relatively vulnerable position at the output of the Word Generator where it could be destroyed by accidental injection of a large-amplitude signal at the WORD OUT terminal.

If the waveform at the collector of Q105 consists of pulses rising from -7 volts to ground and about 300 to 400 nanoseconds in duration at the midpoint, Q105 is all right. If the waveform at the collector of Q105 is not as described, test and replace as necessary both Q105 and CR102.

4.3.3.5 Too Many Pulses in the Pattern. If there are more pulses in the pattern than called for by switch settings, there is more than one pulse circulating in the commutating ring. Either the reset generator is not working, or one or more commutator stages refuse to obey the SET 1 pulse.

Press the SET 0 button. With a dc voltmeter, measure the voltages at AT109, AT110, and AT203. Each voltage should be -2.3 ±0.1 volts. If these voltages are incorrect, check R202 and R203 for proper resistance values.

Set up a cathode-ray oscilloscope for single triggering operation. Connect the oscilloscope to AT109. Press the SET 1 button. A positive pulse should appear, lasting from 50 to 70 milliseconds, and rising from about -2.3 volts to 0 volts. If no such pulse exists, transfer the oscilloscope to AT116 and repeat the test. If the pulse appears at AT116, but not at AT109, the Q127 must be replaced. If no such pulse exists at AT116, check Q125, Q126, CR129, and S920.

4.3.3.6 Too Few Pulses in the Pattern. If there are fewer pulses in the pattern than called for by switch settings, first check that the 14 - 16 switch on the rear panel and the white-green patch wire are set for the desired bit capacity.

If the capacity is set up properly and there are still too few pulses in the pattern, check for an open-circuited diode of the group CR107, CR110, CR113, etc; for a defective switch; or, by far the most likely, one of the brown wires that join the switches to the etched boards has broken loose.

4.3.3.7 Switch Position Skipped. If a switch position is skipped, the commutator ring is shortened. This difficulty differs from that described in paragraph 4.3.3.6, even though a superficial glance may make them seem similar. The distinction is between a non-operating position and a nonexistent position.

Consider the following example. Suppose you successively turn on front-panel switches. Each switch adds a pulse until you come to number 6, where no pulse is added. However, when you turn on number 7, a pulse appears where number 6 should have been. As succeeding switches are turned on, pulses line up after each other, switch 8 controls the 7th position, switch 9 controls the 8th position, etc, until switch 16 adds a 15th pulse and the pattern repeats without a gap between this 15th pulse and the first pulse of the next sequence.

This difficulty is caused by failure of one of the stages (in this example, the 6th) to "latch" when the commutating pulse arrives. When the defective stage tries to operate, it generates a transient that triggers the following stage. The following stage latches and the defective one drops out of the pattern.

Make sure the plug-in capacitors are properly and firmly seated in their jacks. Next, be sure there is adequate drive from the previous stage. For example, if stage 6 does not operate, be sure there is normal voltage at the emitter of Q118, the output of stage 5. Figure 4-2 shows the correct waveform at this emitter.

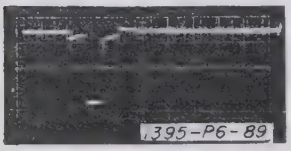


Figure 4-2. Waveform at the emitter of Q118. Vertical scale is 1 volt per major division with ground at the top line of grid; horizontal scale, 5 μs per major division. PRF is 300 kc/s.

If the defective stage is driven properly, replace the transistor in that stage that connects to the 220-ohm resistor. This transistor carries the most current and is the most apt to suffer from a decrease in β or h_{fe}. If the trouble still exists, replace the other transistor in the pair. As a last resort, check all components in the defective stage.

4.3.3.8 One Switch Alters Entire Pattern. This difficulty is caused when an extra commutator pulse is added to the one already circulating around the ring. On the next trip around the ring, each of these two pulses adds another pulse. The ring soon becomes full of circulating pulses, so that any switch may give 6, 8, or more pulses.

The mechanism by which this happens is extremely obscure. It may not be clear why the trouble existed even after it is fixed. Apparently a pulse in one stage feeds forward to another stage if the forward stage is unusually sensitive, and if signal energy from the back (lower-numbered) stage has a place to flow, such as the collecting bus that joins the switch arms. Remember that the trouble does not occur until a front-panel switch is turned on.

Remove the screws that secure the etched boards and swing both boards back. Connect the Word Generator to the main frame with the extension cord. Set the unit for 16-bit looped operation. Drive the CLOCK IN terminal at any convenient frequency. Connect an oscilloscope to the CRO SYNC terminal. Turn off all front-panel switches, push the SET 1 button, and observe the commutator pulse running around the ring. One pulse will be seen for every 16 input pulses.

Now turn on switch 1. The oscilloscope should still show one pulse. Turn on switch 2. The oscilloscope should still display just one pulse because it is looking at the commutator, not the WORD OUT signal. When you turn on switch 3, there should still be just one pulse on the oscilloscope. Add switches in sequence until the pattern becomes erratic.

Suppose turning on switch 7 destroys the pattern. This establishes that the extra pulses originate with a flow of energy from stage 7 to a stage yet to be found.

Following the instructions in paragraph 2.3.3, connect the Word Generator for 15-bit capacity. Turn off all front-panel switches. Push the SET 1 button. Repeat the test just described, turning on the switches in sequence until seven are on. If all is now well, you have established that stage 16 is the one to which the pulse from stage 7 is fed. Replace both transistors in stage 16 and both transistors in stage 7.

If the pattern is again erratic when you turn on switch 7, connect the Word Generator for 14-bit operation and repeat the test. If switch 7 no longer causes difficulty, you know that stage 15 is defective. Replace both transistors in stage 15 and in stage 7.

If the removal of stage 15 does not eliminate the erratic performance, continue to shorten the ring, one stage at a time, until the troublemaker is isolated. Then replace both transistors in the stage into which the extra pulse is inserted, and both transistors in the stage from which the extra pulse originates.

4.3.3.9 Word Generator is Inoperative. If the Word Generator is entirely inoperative, first check the input and connections as described in paragraphs 4.3.1 and 4.3.3.1. When these are correct, proceed with the following tests.

Connect the Word Generator for 16-bit, looped operation. Drive the unit at 300 kc/s from a Type 1395-P1 PRF Unit. Examine the waveform at either AT112 or AT201. This waveform should consist of a series of spikes, rising from approximately -6.8 volts to 0 volts, and about 100 nanoseconds in duration. If such spikes are not present, check and replace if necessary Q107 and Q201. A possible, but less likely fault, is a short- or open-circuited C102, R112, CR104, R111, or C201. If the spikes are present, the trouble is undoubtedly in the ring.

Turn off all front-panel switches. Set the PRF Unit to EXT DRIVE. Set the ΔF control on the PRF Unit to HIGH (CALIBRATED). Press the SET 0 button on the Word Generator. This should turn on transistors Q109, Q111, Q113, Q115, Q117, Q119, Q121, Q123, Q202, Q204, Q206, Q208, Q210, Q212, Q214, and Q216. The collector voltage of each of these transistors should be between 0 and -1 volt. If any voltage is more negative than -1 volt, the stage containing that transistor is the site of the trouble.

Check the voltages on the collectors of Q110, Q112, Q114, Q116, Q118, Q120, Q122, Q124, Q203, Q205, Q207, Q209, Q211, Q213, Q215, and Q217. Each of these voltages should be -7 volts. If any voltage is more positive than about -6.8 volts, the transistor with the high voltage is in the defective stage.

Transistors in the first group (Q109, Q111, Q113, etc) could be shorted and still show correct dc voltages. Transistors in the second group (Q110, Q112, Q114, etc) could be open and have proper dc voltages. Therefore, a pulsing test is needed to find such short- or open-circuited transistors.

Connect the dc voltmeter to the collector of Q109, and press the SET 1 button. The voltage should change from about -0.5 volt to about -4 volts. In the same way, measure the collector voltage of Q110. This should change from -7 volts to -4 volts. If the collector of Q109 stays at -0.5 volt and the collector of Q110 at -7 volts, the trouble is in this stage, which has refused even to enter the SET 1 state, let alone operate with a commutating pulse.

If these voltage changes at Q109 and Q110 are correct, move the voltmeter to the collector of Q112. This voltage should still be about -7 volts. Now generate a single CLOCK IN pulse with the Type 1395-P1 PRF Unit. Either rotate the ΔF control fully counterclockwise and back again fully clockwise, or use a Type 1217-P2 Single-Pulse Trigger. The voltage at the collector of Q112 should now be about -4 volts. If it is still -7 volts, stage 2 (Q111 and Q112) is defective.

If the voltage at Q112 changes to -4 volts, move the voltmeter to the collector of Q114. This will be at -7 volts. Again generate a single pulse and see if the voltage drops to -4 volts. Continue in this way along the commutator until you find the stage at which the voltage refuses to change from -7 volts to -4 volts.

The particular component that is defective will usually have to be found by trial and error. A prudent first guess is a defective transistor. Next check the germanium diodes, then the silicon diodes. Lastly, check the passive components, i.e., resistors and capacitors.

4.4 NORMAL ADJUSTMENTS AND CALIBRATION.

The only adjustment possible in the Type 1395-P6 Word Generator is the power-supply voltage. Connect a dc voltmeter between ground and AT107 or AT212, positive lead grounded. Insert a long, thin screwdriver through the hole at the back edge near the top on board number 1395-0760 and adjust resistor R239 until the voltmeter indicates -7 volts dc.

4.5 MINIMUM PERFORMANCE STANDARD.

TABLE 4-3
TEST EQUIPMENT REQUIRED

Device	*Necessary Specifications*	*Recommended Type**
Modular Pulse Generator (main frame)	(no substitution)	Type 1395-A
Word Generator (in addition to the one under test)	(no substitution)	Type 1395-P6
AC power source	0 to 125 V, variable, with wattmeter	GR Type W5MT3W Metered Variac® Autotransformer
AC impedance bridge	1% accuracy	GR Type 1650 Impedance Bridge
Pulse generator	Capable of producing 10- to 20-V pulses into 400 to 600 Ω with durations between 75 and 150 ns	GR Type 1395-P1 PRF Unit
Audio oscillator	Capable of producing a 60-V signal into 3 kΩ at 10 kHz	GR Type 1311 Audio Oscillator
High-frequency oscillator	Capable of producing 10- to 20-V, 500-kHz to 2.5 MHz sinewaves in 500 Ω	GR Type 1211 Unit Oscillator with Type 1203 Unit Power Supply
Oscilloscope	Bandwidth of at least 30 MHz, calibrated sweep rates	Tektronix Type 543 Oscilloscope with Type L Plug-In Unit and Type P6006 10X probe
Resistor	500- to 600-Ω, 1/2 W	
Resistor	1.2 kΩ ±5%, 1/2 W	
Patch cords (2)	Double plug to double plug	GR Type 274-NQ Patch Cord

*Suitable substitutions may be made, except where noted.

NOTE

This procedure assumes that the Type 1395-A (main frame) is functioning properly in accordance with its own minimum performance standard.

4.5.1 POWER CONSUMPTION.

The following test measures the power consumption of the Type 1395-P6 to be within specified limits.

a. Connect the Type 1395-A to an ac power line via the metered Variac and turn the Type 1395 on.

b. Advance the Variac to 115 volts output while observing the wattmeter. After thirty seconds a relay will close and the power consumption will increase. Note the wattmeter readings before and after the relay closes.

c. Turn off the Type 1395-A and insert the Type 1395-P6 Word Generator into the main frame.

d. Turn the Type 1395-A on. The power consumption before and after the relay closes must have increased by 6 W ±10%.

4.5.2 IMPEDANCE CHECKS.

The following procedures measure the input and output impedance of the word generator to be within specified limits.

Input Impedance.

a. Set the mode switch of the impedance bridge to external ac, and connect its unknown terminals to the CLOCK IN terminals of the Word Generator.

b. Set the impedance bridge controls to measure a resistance in the 100-Ω range.

c. Connect a 1.2-kΩ resistor in series with the output of the audio oscillator and the BIAS terminals of the impedance bridge, if the Type 1650 Impedance Bridge is used. Be sure to remove the connecting link from the BIAS terminals.

d. Set the oscillator frequency to 10 kc/s and the output level to 100 V open circuit. Adjust the output level control so that a 10-V, peak-to-peak, signal appears across the CLOCK IN terminal of the Type 1395-P6.

e. Balance the impedance bridge. The input impedance of the Type 1395-P6 thus measured should be between 400 and 600 Ω.

Output Impedance.

a. Disconnect the audio oscillator from the BIAS terminals of the impedance bridge and replace the link.

b. Set the mode switch of the impedance bridge to obtain an internally generated 1-kc/s test signal, and connect the unknown terminals of the bridge to the WORD OUT terminal of the Type 1395-P6.

c. Measure "R" across the WORD OUT terminals of the Word Generator while it is plugged into a Type 1395-A with the POWER on. Output impedance should be 150 Ω ±20%.

4.5.3 CRO SYNC.

Measure the voltage and duration of the SYNC OUT pulses as follows:

a. Connect a source of 10- to 20-V, 75- to 100-ns, 100-kc/s pulses to the CLOCK IN terminals of the Word Generator.

b. Adjust the controls on an oscilloscope to display a single trace with internal triggering, 0.5 V/div vertical sensitivity and a sweep rate of 10 ns/div.

c. Apply the SYNC OUT signal of the Word Generator to the vertical input of the CRO and press the set 1 button. A single rectangular waveform should be displayed. The amplitude of the waveform must be at least 2 V, and its duration must be equal to the period of the input signal applied to the Word Generator, in this case, 10 μs ±5%. Leave the input signal source connected to the Type 1395-P6.

4.5.4 WORD OUT SIGNAL.

Measure the voltage, duration, and timing of the WORD OUT pulses as follows:

Pulse Characterisitics.

a. Set the input signal frequency to 1 mc/s.

b. Set the oscilloscope controls as follows:

Mode . . . . . dc
Sensitivity . . . . . 5 V/div
Triggering . . . . . external +
Sweep rate . . . . . 2 μs/div

c. Connect the CRO SYNC of the Word Generator to the external trigger input of the CRO and adjust the trigger level control to trigger the CRO on this signal.

c. Set the controls of the Type 1395-P6 Word Generator as follows:

No. 1 switch . . . . . on (toward the center)
LOOP/CARRY switch . LOOP
14/16 switch 16
CARRY OUT switch . . OFF

e. Connect the 500- to 600-Ω resistor across the WORD OUT terminals of the Word Generator. Connect the CRO probe to the upper WORD OUT terminal.

f. Press the SET 1 button and observe that two pulses 16 μs apart are displayed on the CRO. The pulses should be positive-going and should have an amplitude of at least 10 V. The duration measured between half-amplitude points of the pulses should be between 75 and 150 ns. Set the CRO time/div to 20 ns to make the latter measurement.

Pattern.

Use the following procedure to check out the pulse patterns produced by the word generator.

a. Set the CRO time/div back to 2 μs/div.

b. Turn on switches No. 2 through No. 16 and observe that a pulse appears at successive 1-μs intervals for each switch turned ON.

c. Set the 16/14 Switch to 14 and press the Set 1 button. Repeat step b; there will be two fewer pulses in the pattern.

Carry Checks.

The following procedure simultaneously checks the loop and carry functions of two word generators:

a. Turn off the Type 1395-A and insert another Type 1395-P6 into the main frame directly to the right of the first unit. Turn the Type 1395-A back on.

NOTE

The following test will indicate whether or not both Word Generators are performing their CARRY IN/CARRY OUT functions properly. The Word Generators used should be checked out in LOOP operation before being tested in the CARRY mode. If the test fails, the defective Word Generator may be isolated by substitution.

b. Assemble the set-up shown in Figure 4-3. Set the CARRY switches of the Word Generator as shown in this figure. Set the CRO controls as in paragraph 4.5.4 (PULSE CHARACTERISTICS) step a.

c. Set the No. 1 switch on the left-hand Word Generator on (toward the center). All other switches should be off.

d. Press either SET 1 button. Two pulses approximately 23 μs apart should appear on the oscilloscope. These pulses will occur outside the graticule,

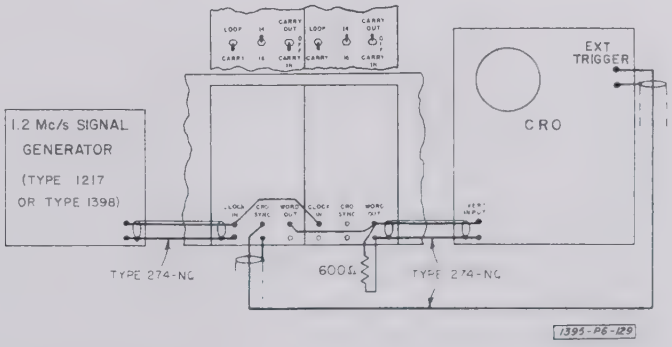


Figure 4-3. Test set-up for carry checks.

and some adjustment of the horizontal control may be necessary to get both pulses on the screen.

e. Interchange the two Word Generators, left to right and right to left.

f. Repeat steps c and d.

g. Turn off the Type 1395-A and remove the right-hand Word Generator.

4.5.4 FREQUENCY AND TRIGGER-REQUIREMENT TESTS.

The following procedure tests the word-generator response to specified input signals.

a. Insert a Type 1395-P2 PULSE DELAY unit into the main frame and turn the Type 1395-A on.

b. Connect the pulse generator to the CLOCK IN terminals of the Word Generator.

c. Connect the CRO SYNC to the trigger synchronizing input of the CRO.

d. Connect a 500- to 600-Ω resistor across the WORD OUT terminals of the Word Generator and apply the output signal from these terminals to the input of the Pulse/Delay Unit.

e. Connect the output of the Pulse/Delay Unit to the vertical input of the CRO.

f. Set the No. 1 switch on the Word Generator on (toward the center). All other front panel switches should be off.

g. Set the LOOP/CARRY switch to LOOP, the CARRY IN/CARRY OUT switch to OFF, and the 14/16 switch to 14.

h. Set the oscilloscope controls as in paragraph 4.5.4, steps b and c, except set the sweep rate to 200 ms/div.

i. Set the pulse generator control to produce a 10- to 20-V, 10-c/s, 100-ns pulse.

j. Set the controls of the Type 1395-P2 for a pulse duration of 20 ms.

k. Push the SET 0 button.

l. Push the SET 1 button and observe that two pulses 1.4 s apart appear on the CRO. Adjust the amplitude of the pulses to a convenient height with the AMPLITUDE control of the Type 1395-P2.

m. Push the SET 0 button. The two pulses should disappear.

n. Repeat steps l and m several times.

o. Repeat steps l and m several times at each of the settings listed in Table 4-4. The pulses should appear and disappear consistently at all settings.

p. Remove the pulse generator and connect a source of 10- to 20-V, 1-Mc/s sinewaves to the CLOCK in terminals.

q. Set the CRO Sweep Rate to 2 μs/div. The pulse duration as set by the Type 1395-P2 should be 200 ns.

r. Repeat steps l and m several times. The two pulses should occur 14 ms apart.

s. Increase the input signal frequency to 2 Mc/s and repeat steps l and m several times. The two pulses should be 7 μs apart.

TABLE 4-4
FREQUENCY AND TRIGGER SIGNAL CHECKS

Duration of CLOCK IN signal	*Frequency of CLOCK IN signal*	*CRO Sweep Rate Time/div*	*Pulse Duration Set by Type 1395-P2*	*Separation between Resulting Pulses*
100 ns	100 c/s	20 ms	2 ms	140 ms
100 ns	1 kc/s	2 ms	200 μs	14 ms
100 ns	10 kc/s	200 μs	20 μs	1.4 ms
5 μs	100 kc/s	20 μs	2 μs	140 μs
0.42 μs	1.2 Mc/s	2 μs	200 ns	11.6 μs

NOTE

The unit of frequency is the hertz, which is equivalent to one cycle per second. The abbreviation of hertz is Hz, which is used in more recently included sections of this book, replacing the older c/s.

PARTS LIST

REF NO.	DESCRIPTION	PART NO.	FMC	MFG. PART NO.	FED. STOCK NO.
CAPACITORS					
C101	Ceramic, 100 pF ±5% 500 V	4404-1105	72982	831, 100 pF ±5%	
C102	Ceramic, 100 pF ±5% 500 V	4404-1105	72982	831, 100 pF ±5%	
C103	Ceramic, 0.1 µF +80 -20% 50 V	4403-4100	80131	CC63, 0.1 µF +80-20%	5910-811-4788
C104	Ceramic, 0.01 µF +80 -20% 50 V	4401-3100	80131	CC61, 0.01 µF +80-20%	5910-974-5697
C105	Ceramic, 0.001 µF ±5% 500 V	4405-2105	72982	801, 0.001 µF ±5%	
C106	Ceramic, 0.1 µF +80 -20% 50 V	4403-4100	80131	CC63, 0.1 µF +80-20%	5910-811-4788
C107	Ceramic, 0.1 µF ±20% 25 V	4400-2050	80183	5C13, 0.1 µF ±20%	5910-974-5695
C108	Ceramic, 27 pF ±5% N750 500 V	4417-0275	80131	CC60, 27 pF ±5%	
C109	Ceramic, 100 pF ±5% 500 V	4404-1105	72982	831, 100 pF ±5%	
C110	Ceramic, 100 pF ±5% 500 V	4404-1105	72982	831, 100 pF ±5%	
C111	Ceramic, 27 pF ±5% N750 500 V	4417-0275	80131	CC60, 27 pF ±5%	
C112	Ceramic, 100 pF ±5% 500 V	4404-1105	72982	831, 100 pF ±5%	
C113	Ceramic, 27 pF ±5% N750 500 V	4417-0275	80131	CC60, 27 pF ±5%	
C114	Ceramic, 100 pF ±5% 500 V	4404-1105	72982	831, 100 pF ±5%	
C115	Ceramic, 27 pF ±5% N750 500 V	4417-0275	80131	CC60, 27 pF ±5%	
C116	Ceramic, 100 pF ±5% 500 V	4404-1105	72982	831, 100 pF ±5%	
C117	Ceramic, 27 pF ±5% N750 500 V	4417-0275	80131	CC60, 27 pF ±5%	
C118	Ceramic, 100 pF ±5% 500 V	4404-1105	72982	831, 100 pF ±5%	
C119	Ceramic, 27 pF ±5% 500 V	4417-0275	80131	CC60, 27 pF ±5%	
C120	Ceramic, 100 pF ±5% 500 V	4404-1105	72982	831, 100 pF ±5%	
C121	Ceramic, 27 pF ±5% N750 500 V	4417-0275	80131	CC60, 27 pF ±5%	
C122	Ceramic, 100 pF ±5% 500 V	4404-1105	72982	831, 100 pF ±5%	
C123	Ceramic, 27 pF ±5% 500 V	4417-0275	80131	CC60, 27 pF ±5%	
C124	Ceramic, 0.1 µF +80 -20% 50 V	4403-4100	80131	CC63, 0.1 µF +80-20%	5910-811-4788
C125	Ceramic, 47 pF ±10% 500 V	4404-0478	72982	831, 47 pF ±10%	
C126	Ceramic, 330 pF ±5% 500 V	4404-1335	72982	831, 330 pF ±5%	
C127	Ceramic, 2.2 µF ±20% 25 V	4400-2080	24655	4400-2080	
C128	Ceramic, 0.22 µF ±20% 25 V	4400-2052	80183	5C13, 0.22 µF ±20%	
C201	Ceramic, 68 pF ±5% 500 V	4404-0685	72982	831, 68 pF ±5%	
C202	Ceramic, 100 pF ±5% 500 V	4404-1105	72982	831, 100 pF ±5%	
C203	Ceramic, 27 pF ±5% N750 500 V	4417-0275	80131	CC60, 27 pF ±5%	
C204	Ceramic, 100 pF ±5% 500 V	4404-1105	72982	831, 100 pF ±5%	
C205	Ceramic, 27 pF ±5% N750 500 V	4417-0275	80131	CC60, 27 pF ±5%	
C206	Ceramic, 100 pF ±5% 500 V	4404-1105	72982	831, 100 pF ±5%	
C207	Ceramic, 27 pF ±5% N750 500 V	4417-0275	80131	CC60, 27 pF ±5%	
C208	Ceramic, 100 pF ±5% 500 V	4404-1105	72982	831, 100 pF ±5%	
C209	Ceramic, 27 pF ±5% N750 500 V	4417-0275	80131	CC60, 27 pF ±5%	
C210	Ceramic, 100 pF ±5% 500 V	4404-1105	72982	831, 100 pF ±5%	
C211	Ceramic, 27 pF ±5% N750 500 V	4417-0275	80131	CC60, 27 pF ±5%	
C212	Ceramic, 100 pF ±5% 500 V	4404-1105	72982	831, 100 pF ±5%	
C213	Ceramic, 27 pF ±5% N750 500 V	4417-0275	80131	CC60, 29 pF ±5%	
C214	Ceramic, 100 pF ±5% 500 V	4404-1105	72982	831, 100 pF ±5%	
C215	Ceramic, 27 pF ±5% N750 500 V	4417-0275	80131	CC60, 27 pF ±5%	
C216	Ceramic, 100 pF ±5% 500 V	4404-1105	72982	831, 100 pF ±5%	
C217	Ceramic, 27 pF ±5% N750 500 V	4417-0275	80131	CC60, 27 pF ±5%	
C218	Electrolytic, 100 µF +100 -10% 25 V	4450-2300	76149	20-40595	5910-799-9284
C219	Electrolytic, 100 µF +100 -10% 25 V	4450-2300	76149	20-40595	5910-799-9284
C901A C901B C901C	Electrolytic, 700 µF 350 µF +100 -10% 50 V 350 µF	4450-2660	37942	TT, 700/350/350 µF +100-10%	
C902	Ceramic, 0.01 µF +80 -20% 500 V	4406-3109	72982	811, 0.01 µF +80-20%	5910-754-7049
DIODES					
CR102	Type 1N625	6082-1012	24446	1N4009	
CR103	Type 1N994	6082-1017	24446	1N994	
CR104	Type 1N191	6082-1008	93916	1N191	5961-296-3360
CR105	Type 1N191	6082-1008	93916	1N191	5961-296-3360
CR106	Type 1N625	6082-1012	24446	1N4009	
CR107	Type 1N191	6082-1008	93916	1N191	5961-296-3360
CR108	Type 1N191	6082-1008	93916	1N191	5961-296-3360
CR109	Type 1N625	6082-1012	24446	1N4009	
CR110	Type 1N191	6082-1008	93916	1N191	5961-296-3360
CR111	Type 1N191	6082-1008	93916	1N191	5961-296-336
CR112	Type 1N625	6082-1012	24446	1N4009	

PARTS LIST (continued)

REF NO.	DESCRIPTION	PART NO.	FMC	MFG. PART NO.	FED. STOCK NO.
DIODES					
CR113	Type 1N191	6082-1008	93916	1N191	5961-296-3360
CR114	Type 1N191	6082-1008	93916	1N191	5961-296-3360
CR115	Type 1N625	6082-1012	24446	1N4009	
CR116	Type 1N191	6082-1008	93916	1N191	5961-296-3360
CR117	Type 1N191	6082-1008	93916	1N191	5961-296-3360
CR118	Type 1N625	6082-1012	24446	1N4009	
CR119	Type 1N191	6082-1008	93916	1N191	5961-296-3360
CR120	Type 1N191	6082-1008	93916	1N191	5961-296-3360
CR121	Type 1N625	6082-1012	24446	1N4009	
CR122	Type 1N191	6082-1008	93916	1N191	5961-296-3360
CR123	Type 1N191	6082-1008	93916	1N191	5961-296-3360
CR124	Type 1N625	6082-1012	24446	1N4009	
CR125	Type 1N191	6082-1008	93916	1N191	5961-296-3360
CR126	Type 1N191	6082-1008	93916	1N191	5961-296-3360
CR127	Type 1N625	6082-1012	24446	1N4009	
CR128	Type 1N191	6082-1008	93916	1N191	5961-296-3360
CR129	Type 1N625	6082-1012	24446	1N4009	
CR130	Type 1N625	6082-1012	24446	1N4009	
CR201 through CR208	Type 1N191	6082-1008	93916	1N191	5961-296-3360
CR210	Type 1N191	6082-1008	93916	1N191	5961-296-3360
CR211	Type 1N625	6082-1012	24446	1N4009	
CR212	Type 1N191	6082-1008	93916	1N191	5961-296-3360
CR213	Type 1N625	6082-1012	24446	1N4009	
CR214	Type 1N191	6082-1008	93916	1N191	5961-296-3360
CR215	Type 1N625	6082-1012	24446	1N4009	
CR216	Type 1N191	6082-1008	93916	1N191	5961-296-3360
CR217	Type 1N625	6082-1012	24446	1N4009	
CR218	Type 1N191	6082-1008	93916	1N191	5961-296-3360
CR219	Type 1N625	6082-1012	24446	1N4009	
CR220	Type 1N191	6082-1008	93916	1N191	5961-296-3360
CR221	Type 1N625	6082-1012	24446	1N4009	
CR222	Type 1N191	6082-1008	93916	1N191	5961-296-3360
CR223	Type 1N625	6082-1012	24446	1N4009	
CR224	Type 1N191	6082-1008	93916	1N191	5961-296-3360
CR225	Type 1N625	6082-1012	24446	1N4009	
CR226 through CR229	Type 1N3253	6081-1001	79089	1N3253	5961-814-4251
CR230	Type 1N752	6083-1004	07910	1N752	
DELAY LINE					
DL101	0.15-μs, 1 kΩ, PCA Elec., Inc. No. DL1000A-0.15A	1395-0400	24655	1395-0400	
JACKS					
J901	CLOCK IN, Metal Bushing	4150-3200	24655	4150-3200	
J902	CRY SYNC, Metal Bushing	4150-3200	24655	4150-3200	
J903	WORD OUT, Metal Bushing	4150-3200	24655	4150-3200	
J904	Gnd, Forced Insert	5440-2727	24655	5440-2727	
J905	Gnd, Forced Insert	5440-2727	24655	5440-2727	
J906	Gnd, Forced Insert	5440-2727	24655	5440-2727	
INDUCTOR					
L201	Choke, 2.7 μH ±10%	4300-1300	99800	1537-22, 2.7 μH ±10%	
PLUG					
PL901	14 Connector, Female, Amphenol No. 57-10140	4220-5307	02660	57-10140	

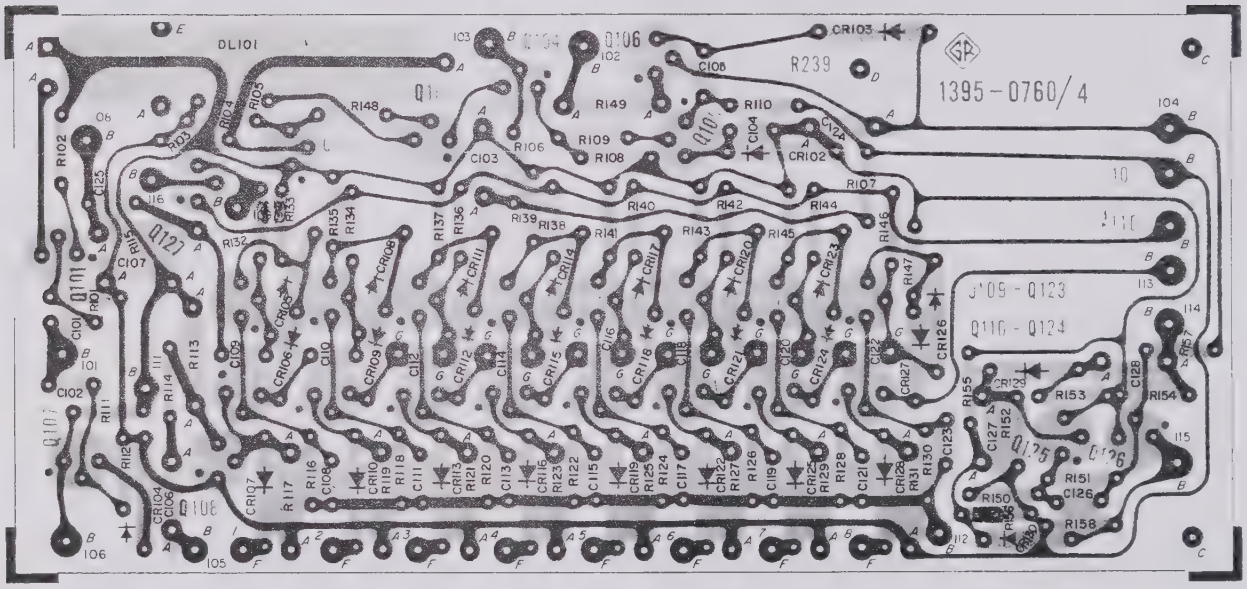


Figure 4-4. Etched-board layout for SET 0 – SET 1 system, gate, word-out amplifier and first half of ring counter (P/N 1395-2761).

NOTE: The number appearing on the etched board is the number of the board only, without circuit components. When ordering a new etched-board assembly, use the part number in the parts list.

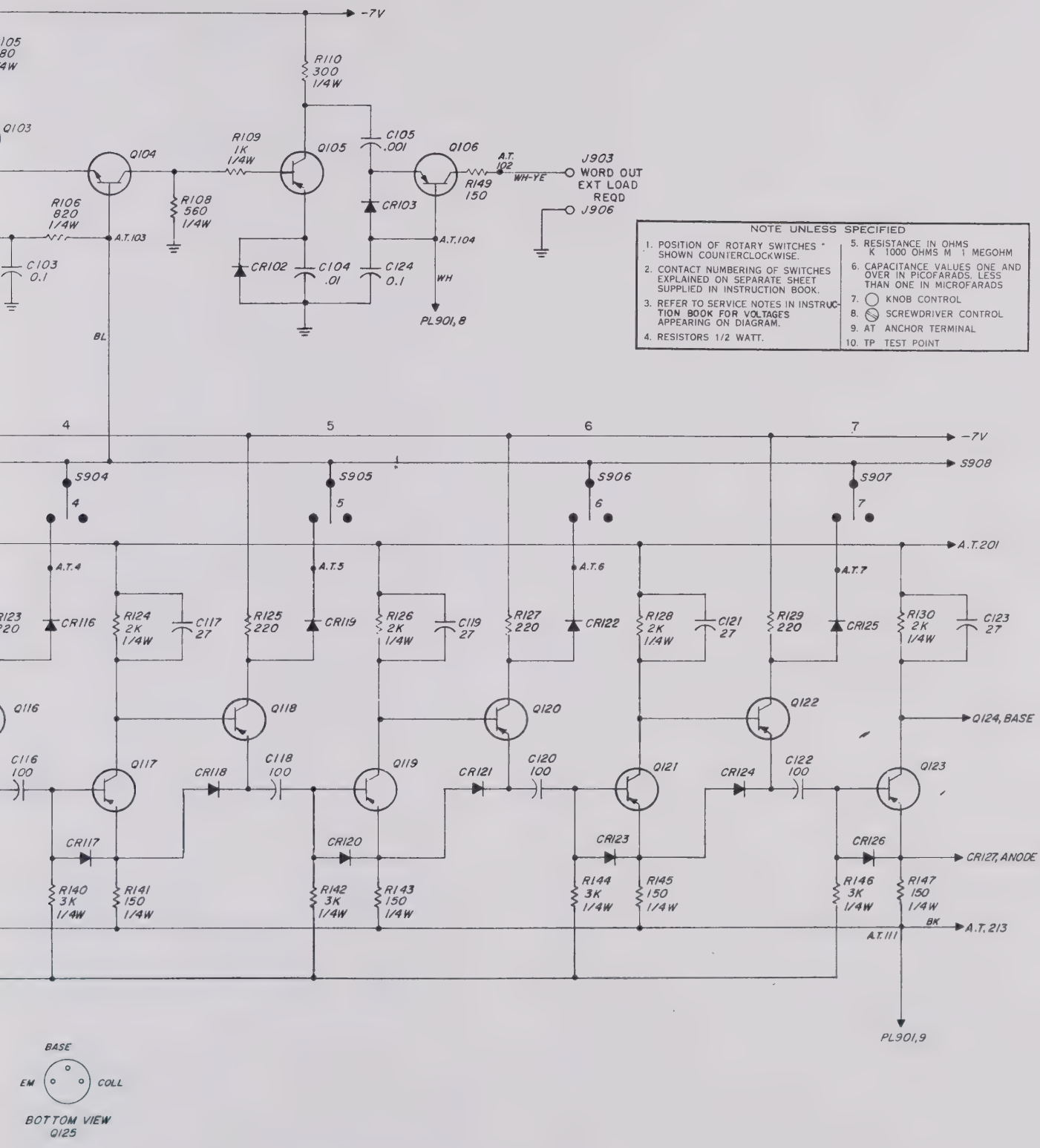


Figure 4-5. Schematic diagram, of SET 0 – SET 1 system, gate, word-out amplifier and first half of ring counter.

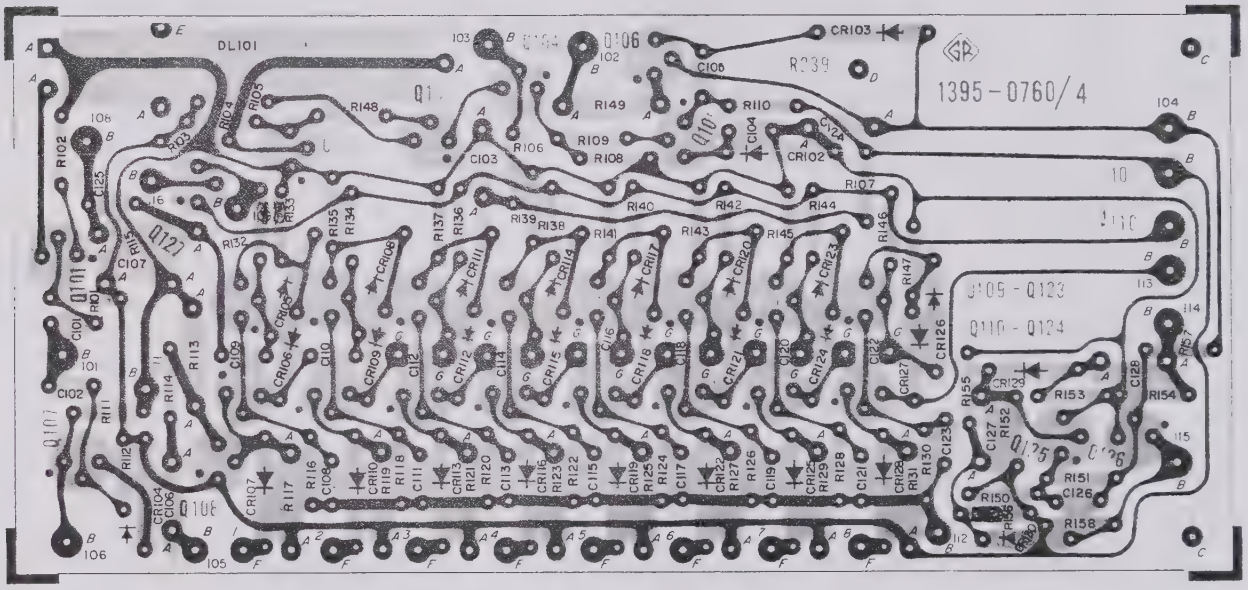


Figure 4-4. Etched-board layout for SET 0 – SET 1 system, gate, word-out amplifier and first half of ring counter (P/N 1395-2761).

NOTE: The number appearing on the etched board is the number of the board only, without circuit components. When ordering a new etched-board assembly, use the part number in the parts list.

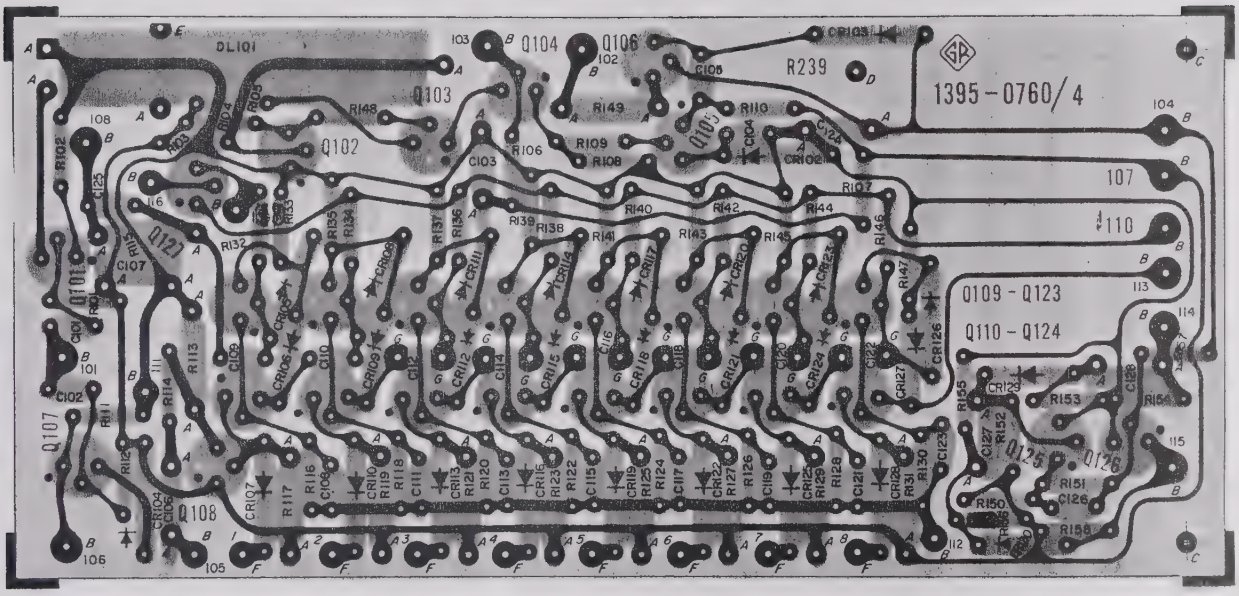
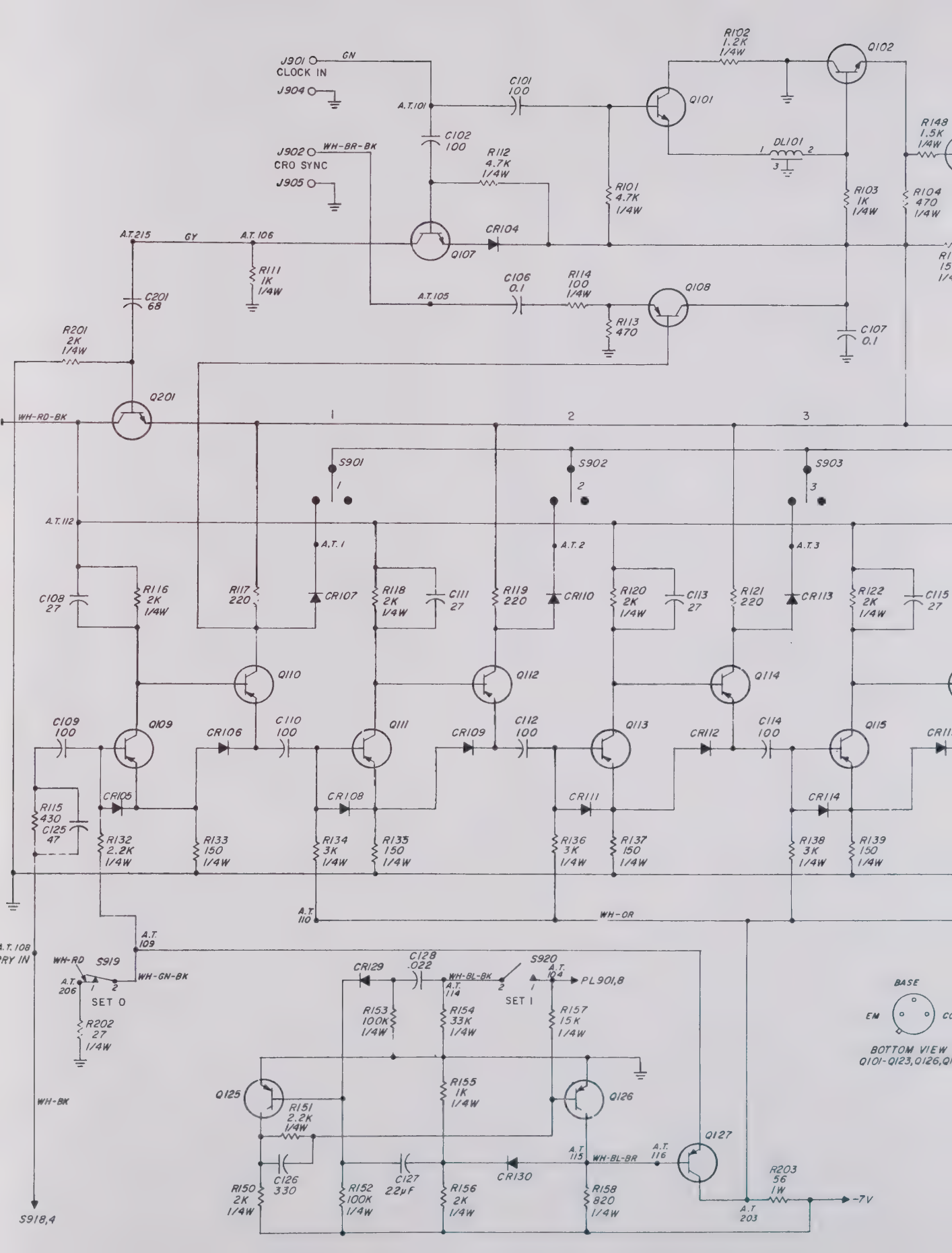


Figure 4-4. Etched-board layout for SET 0 – SET 1 system, gate, word-out amplifier and first half of ring counter (P/N 1395-2761).

NOTE: The number appearing on the etched board is the number of the board only, without circuit components. When ordering a new etched-board assembly, use the part number in the parts list.


J901 CLOCK IN
GN
J904
J902 CRO SYNC
WH-BR-BK
J905
A.T.101
C101 100
C102 100
R112 4.7K 1/4W
R102 1.2K 1/4W
Q102
Q101
DL101
R148 1.5K 1/4W
R101 4.7K 1/4W
R103 1K 1/4W
R104 470 1/4W
A.T.215
GY
A.T.106
CR104
Q107
R111 1K 1/4W
C201 68
C106 0.1
R114 100 1/4W
A.T.105
Q108
R113 470
C107 0.1
R201 2K 1/4W
Q201
WH-RD-BK
1
2
3
S901
S902
S903
A.T.112
A.T.1
A.T.2
A.T.3
C108 27
R116 2K 1/4W
R117 220
CR107
R118 2K 1/4W
C111 27
R119 220
CR110
R120 2K 1/4W
C113 27
R121 220
CR113
R122 2K 1/4W
C115 27
Q110
Q112
Q114
C109 100
Q109
CR106
C110 100
Q111
CR109
C112 100
Q113
CR112
C114 100
Q115
CR105
CR108
CR111
CR114
R115 430
C125 47
R132 2.2K 1/4W
R133 150 1/4W
R134 3K 1/4W
R135 150 1/4W
R136 3K 1/4W
R137 150 1/4W
R138 3K 1/4W
R139 150 1/4W
A.T. 110
WH-OR
A.T. 108
RY IN
A.T. 109
WH-RD
S919
A.T. 206
WH-GN-BK
SET 0
R202 27 1/4W
WH-BK
S918,4
CR129
C128 .022
WH-BL-BK
A.T. 114
S920
A.T. 104
PL901,8
SET 1
R153 100K 1/4W
R154 33K 1/4W
R157 15K 1/4W
R155 1K 1/4W
Q125
Q126
R151 2.2K 1/4W
Q127
A.T. 115
WH-BL-BR
A.T. 116
C126 330
C127 .22μF
CR130
R150 2K 1/4W
R152 100K 1/4W
R156 2K 1/4W
R158 820 1/4W
R203 56 1W
A.T. 203
-7V
BASE
EM
BOTTOM VIEW
Q101-Q123,Q126,Q

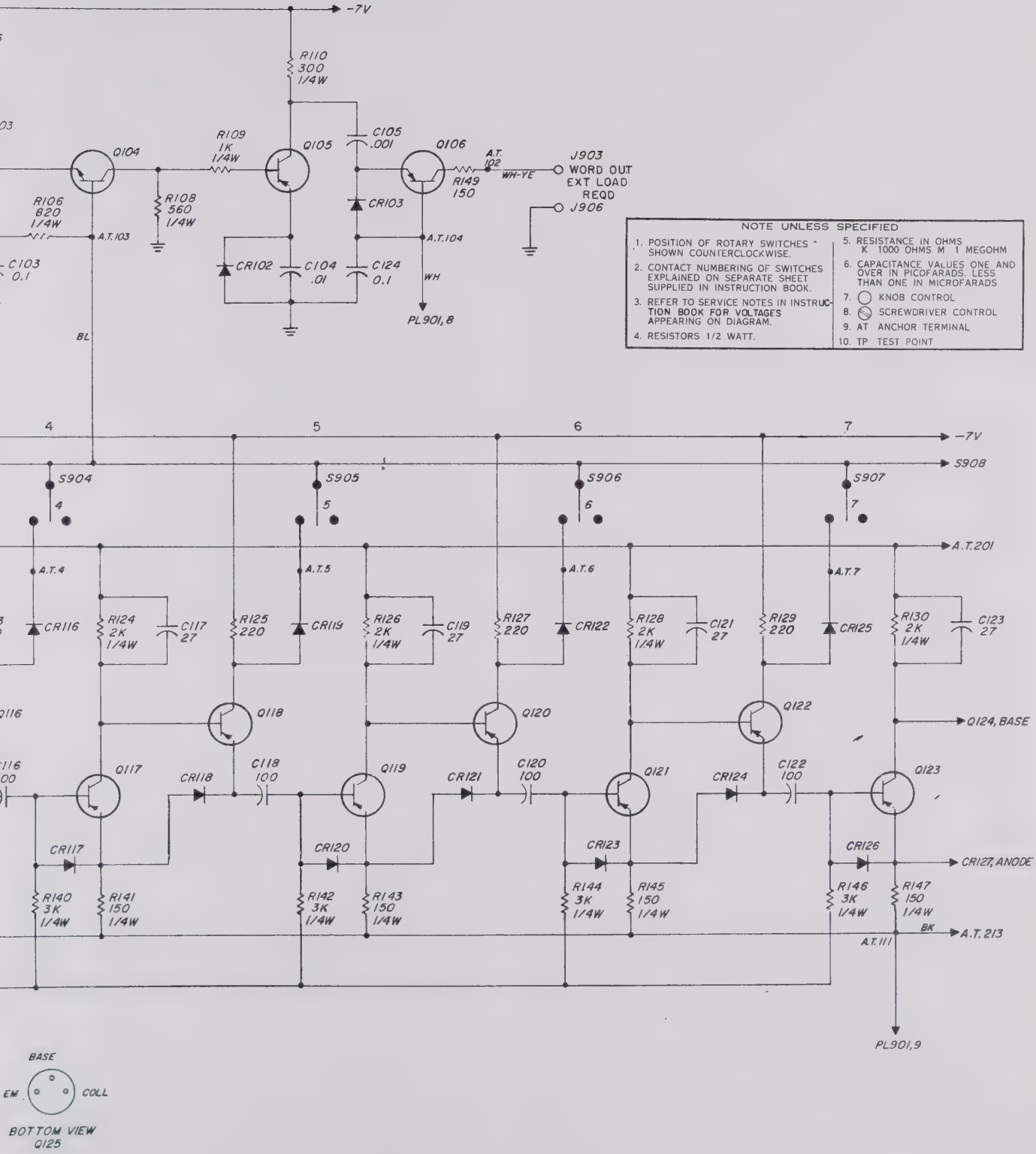


Figure 4-5. Schematic diagram, of SET 0 – SET 1 system, gate, word-out amplifier and first half of ring counter.

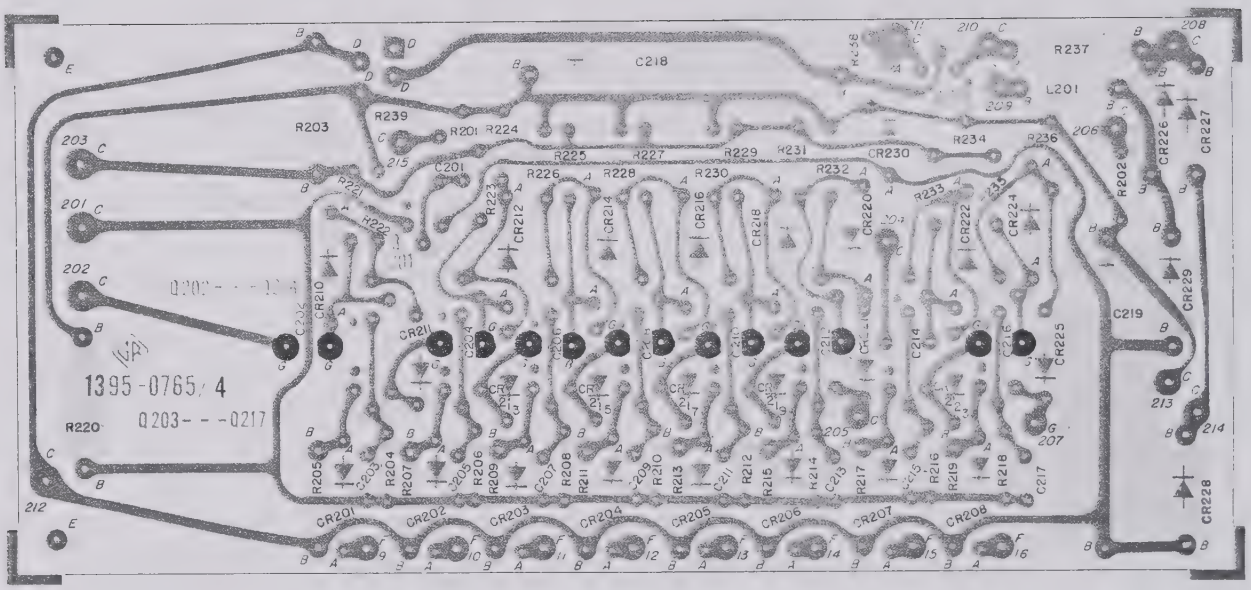
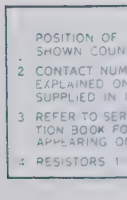


Figure 4-5. Etched board layout for power supply and second helf of ring counter (P/N 1395-1765).

NOTE: The number appearing on the etched board is the number of the board only, without circuit components. When ordering a new etched-board assembly, use the part number in the parts list.



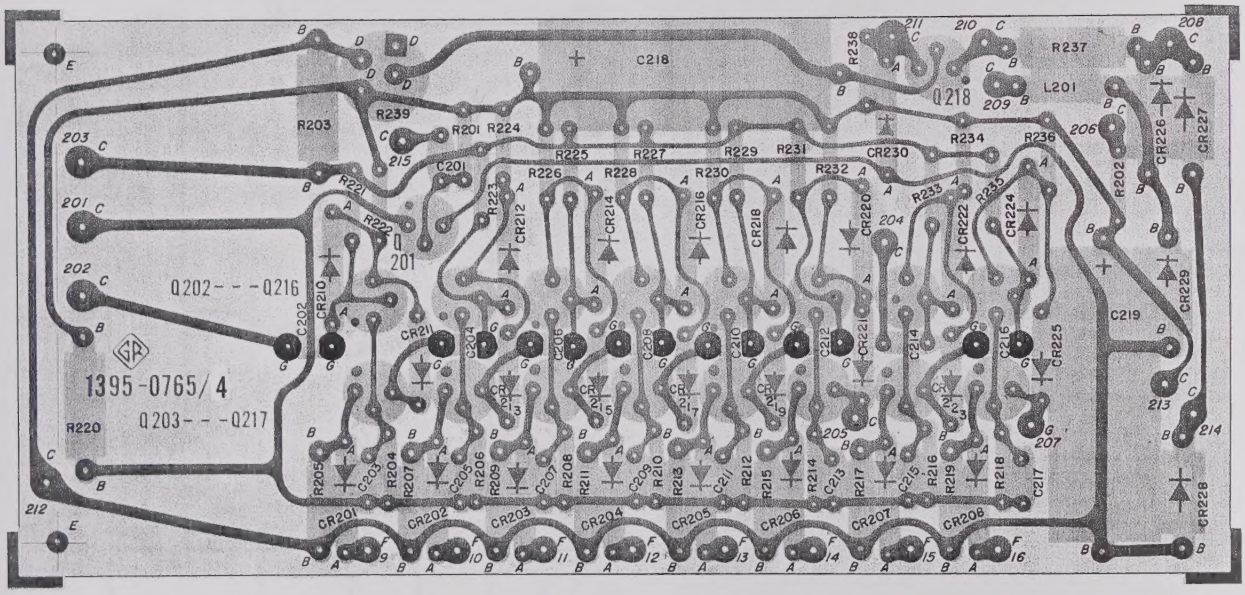


Figure 4-5. Etched board layout for power supply and second helf of ring counter (P/N 1395-1765).

NOTE: The number appearing on the etched board is the number of the board only, without circuit components. When ordering a new etched-board assembly, use the part number in the parts list.

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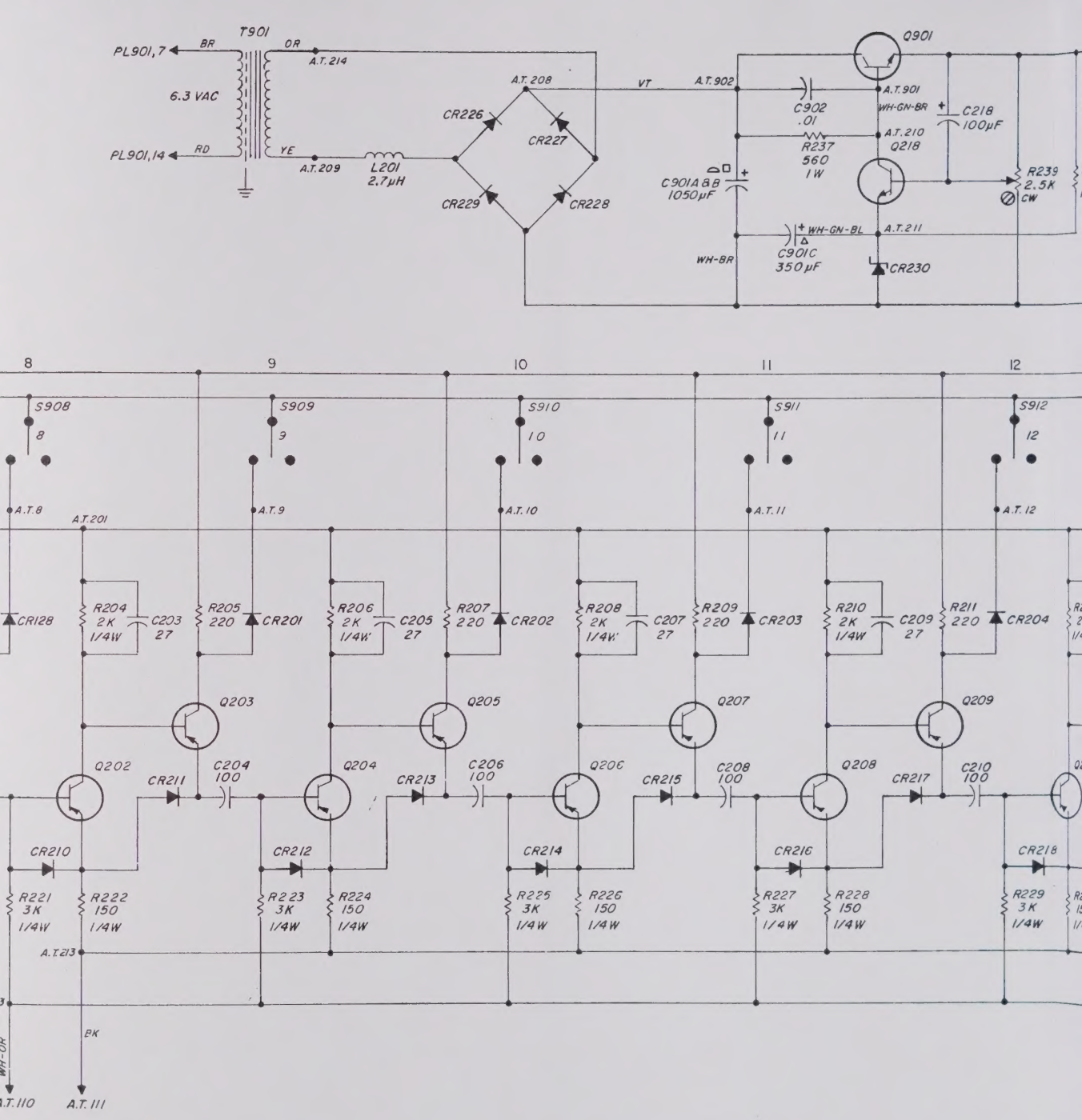
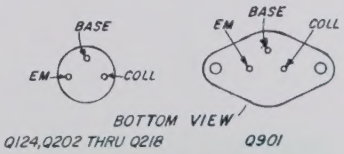
APPEARING
4. RESISTORS





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5. RESISTANCE IN OHMS K 1000 OHMS M 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS. LESS THAN ONE IN MICROFARADS.
7. ◯ KNOB CONTROL
8. ⊘ SCREWDRIVER CONTROL
9. AT ANCHOR TERMINAL
10. TP TEST POINT

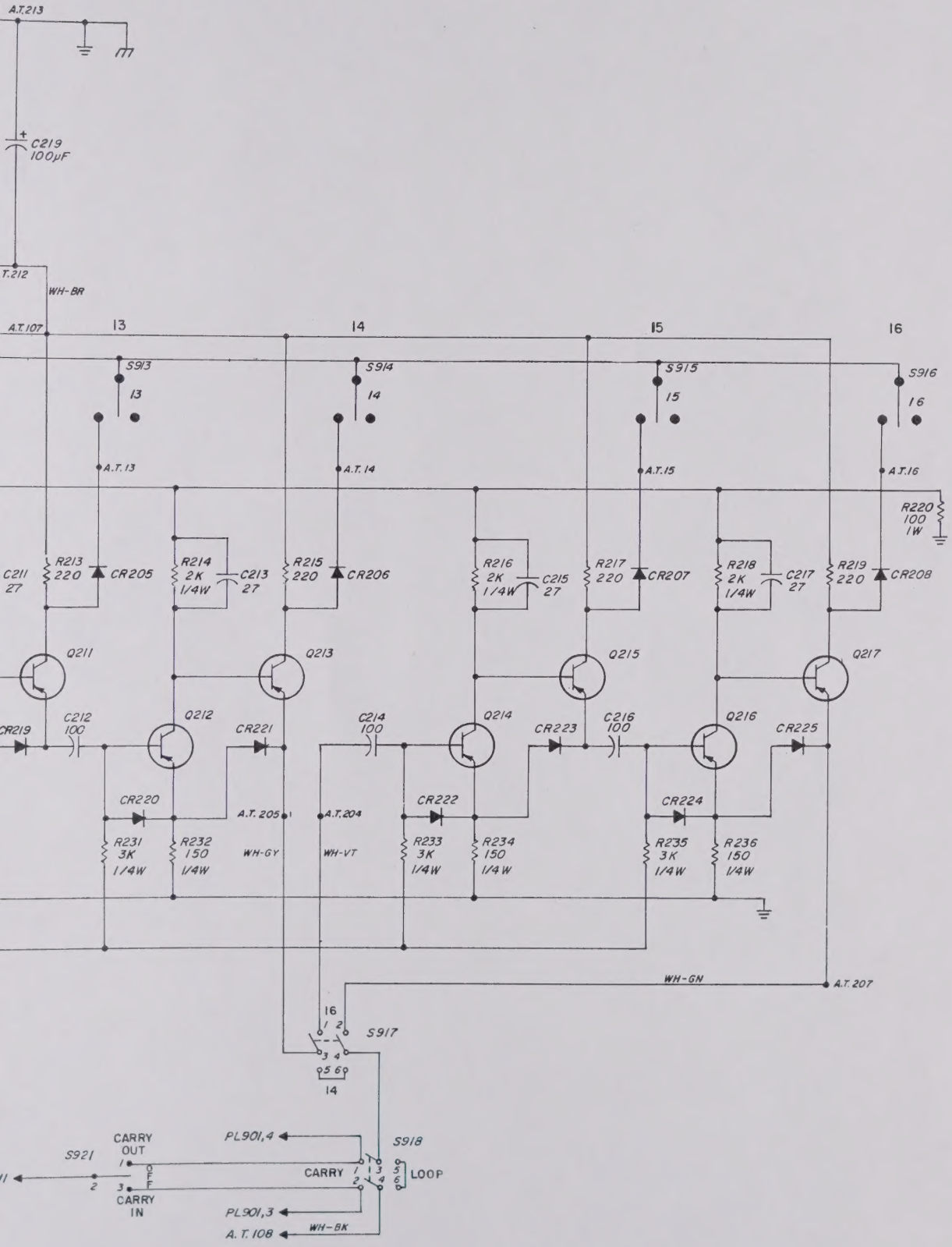

Figure 4-6. Schematic diagram of power supply and second half of ring counter.

MP MASTER
MA29555